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Waste-derived Fuel as a Supplementary Energy Source at the Woodstock Cement Plant

Report EPS 3/UP/6
April 1992

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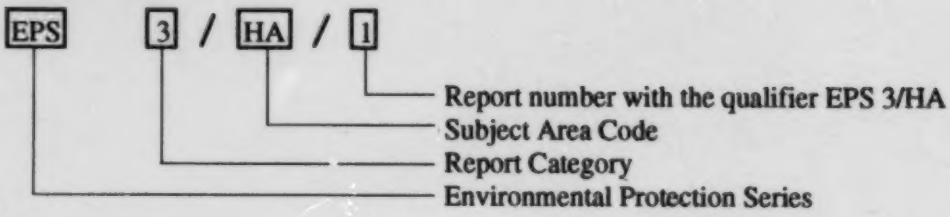

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Abstract

The manufacture of cement is an energy-intensive process. By burning waste fuels to recover their energy value, a typical cement kiln can burn 113 500 L of liquid waste per day, providing 20 to 25% of a kiln's daily heat requirement. The total quantity of liquid industrial organic wastes generated in Ontario annually is over 1 000 000 tonnes.

Lafarge Canada Incorporated initially considered the idea of using waste-derived fuels as a supplementary energy source in 1982. Following the successful completion of a preliminary evaluation program, the company embarked on a project to investigate the process and both the product and environmental impact of burning liquid industrial wastes in its cement kiln at Woodstock, Ontario. Over a 90-day period, all aspects of the test burn were monitored and documented, including fuel procurement and handling, fuel combustion and emissions monitoring, emergency response and, ultimately, closure of the test program. This information, along with the economic, environmental and energy-saving implications of the waste-derived fuel project, is documented in this report. In addition, Lafarge has documented the various steps that were taken in an effort to keep the local public informed and to gain their acceptance. The level of success and failure in the public information program is examined.

Résumé

La fabrication du ciment requiert une grande consommation d'énergie. Un four à ciment typique peut brûler quelque 113 500 L de déchets liquides par jour pour en récupérer le contenu énergétique, ce qui assure de 20 à 25 % des besoins thermiques quotidiens d'un four. En Ontario, la production annuelle de déchets organiques industriels liquides dépasse un million de tonnes.

Lafarge Canada Inc. avait envisagé en 1982 la possibilité d'utiliser des combustibles dérivés de déchets comme source d'énergie d'appoint. Après la réussite d'un programme d'évaluation préliminaire, la société a entrepris d'étudier plus à fond, à son four à ciment de Woodstock en Ontario, les diverses facettes de la combustion de déchets industriels liquides, à savoir la technique elle-même ainsi que ses effets sur les produits et l'environnement. Pendant 90 jours, on a surveillé et documenté tous les aspects de cette combustion expérimentale, y compris l'approvisionnement en combustible et sa manutention, la combustion du combustible et les émissions, les mesures d'urgence et le parachèvement du programme expérimental. Le présent rapport contient ces données et traite également des divers aspects de ce projet en terme de coûts, d'environnement et d'économies d'énergie. De plus, la société Lafarge a documenté les diverses étapes entreprises afin de tenir au courant le public sur ce projet et d'obtenir son acceptation. Le rapport examine également le degré de succès et d'échec du programme d'information publique.

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Summary

Principal Objective

Lafarge Canada's cement plant in Woodstock, Ontario, is an older generation plant (built in 1955) which uses the energy-intensive "wet" manufacturing process. To maintain its competitiveness in a market supplied predominantly by newer plants, the Woodstock plant had to introduce ways to reduce its manufacturing costs. In 1982, the company began studying the use of liquid combustible wastes as a supplementary fuel for Woodstock's cement kilns. The principal objective was to reduce energy costs, which accounted for 21% of the plant's total manufacturing costs.

Experience in Waste Management Operations

Lafarge has been burning waste-derived fuels at its Paulding, Ohio plant since 1979, and has resource recovery installations at three other plants in the United States. These facilities are managed by the group's wholly-owned waste management division SYSTECH Corporation of Xenia, Ohio. SYSTECH also operates installations at Los Robles, California (a former Lafarge plant now owned by National Cement), and at Lone Star Cement's plant at Greencastle, Indiana. Several other plants are in the permit application process.

The Advantages of Burning Wastes in Cement Kilns

Tests conducted throughout North America and Europe demonstrate conclusively that the burning of wastes as supplementary fuel in cement kilns is environmentally safe and technically sound. The technology has three major advantages:

- the wastes are completely destroyed and no longer a threat to the environment;
- the recovery of their energy value provides significant fuel savings to the cement industry; and
- the economics of this technology make it more attractive than many other disposal methods.

Waste Generation and Disposal in Ontario

Industry in Ontario generates 1.0×10^6 t of combustible waste per year. The provincial waste disposal system is currently strained by the limited number of approved facilities. It is estimated that, of the wastes that would be suitable for use at Woodstock, as much as half are transported out of the province for disposal or reuse. The rest of the waste is handled within the province by

incineration or landfilling. Using wastes as supplementary fuel in cement kilns could provide Ontario generators with a more economical and accessible waste disposal system.

Studies show that there is a more than ample supply of wastes being generated in Ontario to support a resource recovery installation at Woodstock. The materials proposed for use include a wide range of liquid organic combustible wastes.

Preliminary and Extended Test Burns

A short preliminary test burn to establish the general feasibility of using waste-derived fuel was conducted at Woodstock at the end of September 1982. A 90-day extended test burn followed a year later from October to December, 1983 under three temporary permits from the Ontario Ministry of the Environment (MOE). The objectives of the extended burn were to study:

- environmental impact;
- occupational health and safety impact;
- cement quality;
- suitability of a fuel procurement program;
- public involvement;
- stability of operation;
- equipment suitability;
- transportation of liquid wastes; and
- suitability of an emergency response plan.

Results of the Extended Test Burn

Monitoring of the test burn was carried out by the MOE and the Ontario Research Foundation (ORF). Baseline monitoring was conducted prior to using liquid wastes. Test data were then gathered at 20% and 40% fuel replacement by wastes. The results indicated that there is no significant difference in stack emission levels when burning combustible liquid waste. In fact, for particulate matter, the emission rate from the kiln stack dropped when the wastes were utilized. High levels of cadmium were detected in two of the nine leachate tests on kiln waste dust following the incineration of liquid waste at the 40% fuel replacement level. However, since the time of the extended test burn, changes have been made in the manufacturing process. The return dust is now returned to the kiln process and becomes part of the finished product (clinker), rather than a waste disposed of in the on-site landfill.

After the extended test burn, the MOE requested that the Woodstock plant improve fugitive dust control in a number of areas. A control order, served in April 1986, specified that

Lafarge should propose and implement improvement measures according to a negotiated schedule. Twelve areas of concern were identified, and two additional concerns have since been added.

The company decided to delay applying for an environmental hearing to burn combustible wastes until it had complied with the requirements of the control order. Excellent progress has been achieved in this regard. Practical engineering solutions have been sought and employed so that the improvements have become a permanent part of the plant's operation.

The extended test burn demonstrated that all other aspects of the proposed waste management installation were satisfactory.

Public Information Program

Woodstock's public information program was designed to:

- explain the proposed facility to the various public interest groups involved;
- outline Lafarge Canada's reasons for wishing to burn waste as supplementary fuel; and
- keep the public informed of the project's progress.

The basic strategy was to communicate first with employees, secondly with local officials, government representatives, community leaders and environmental interest groups, and thirdly with the general public. The information program was deliberately low key but it was also personal, comprehensive, responsive and well organized. The emphasis was placed on going out to meet people, and on understanding and addressing their concerns. To foster a consistent approach for the information program, the plant manager represented the company whenever possible. He was assisted by other Lafarge and SYSTECH experts when the occasion warranted.

In addition to meetings, the plant held a two-month-long "open house" during the extended test burn so that local citizens could observe the waste management facility in operation. The reasons for Lafarge's wish to burn wastes at Woodstock were explained in the course of the program, as were the technology and the type of operation involved. The link between fuel economy and the viability of the plant was discussed, as well as the cement manufacturing process and the types of materials proposed for use as supplementary fuel. After the extended test burn, test results were also communicated to the public. Press coverage of the project was extensive and generally fair. The company gave interviews to the local media and provided them with all necessary information.

Costs and Financial Feasibility

A permanent resource recovery installation at Woodstock could replace 20% of conventional fuel with 2.0×10^7 L of organic wastes generated by industry in Ontario. Under the proposed supply arrangements, the plant would purchase the waste-derived fuels at 50% of the average cost of conventional fuels, and would receive 50% of net disposal revenue. The cost of building the receiving and storage facilities was estimated to be $1 200 000. When energy prices are low, the fuel cost savings alone do not justify the capital investment. However, coupled with the shared disposal revenue, the project is economically attractive and will become more so in the long term as energy prices increase.

Applicability on a National Scale

There are economic benefits to be gained by applying this proven technology on a national scale. Adding facilities to receive, test, and store wastes at existing cement plants is much less expensive than building new disposal sites. Other benefits include the strengthening of the Canadian cement industry as a whole through a reduction in manufacturing costs, the replacement of imported fuels such as coal, and a reduction in the need to transport hazardous wastes by having many cement plant sites rather than a few incinerators in remote areas.

Current Status of the Project

Woodstock is making significant and sustained progress in complying with the requirements of the control order and is in the process of obtaining a permit for its landfill site. Two public meetings have been held to report on progress in these areas. In response to the plant's improved performance, the local opposition group raised no objection to the MOE's decision that no public hearing need be held regarding the granting of the landfill permit.

Woodstock is now studying five possible approaches for the future:

1. apply for a full permit to burn liquid wastes;

2. conduct a longer-term trial (one to two years) under a temporary test permit;

3. select and burn a single waste (e.g., a solvent) available in large quantities--once this has been done successfully, look to expanding the types of wastes used;

4. study the possibility of burning some other type of waste, such as rubber tires; and

5. discontinue the project entirely, if the regulatory, political and social ambiance is such that the permitting process for resource recovery installations becomes too costly and time-consuming.

The experience at Woodstock has proved that burning liquid combustible wastes as supplementary fuel in cement kilns is an environmentally safe, technically sound and economically feasible solution to the growing problem of waste disposal. The cement kiln option should become an integral part of the waste management strategy for Ontario and Canada.

Section 1

Introduction

Lafarge Canada Inc. began considering the use of waste-derived fuels at its Woodstock, Ontario cement plant in 1982. The company had studied successful applications of this technology in the United States and Europe, especially the facility at the Paulding, Ohio cement plant of its U.S. sister company, General Portland Inc. The Paulding plant has been successfully burning waste-derived fuels since 1979.

In September 1982, Lafarge conducted a 100-h preliminary test burn at Woodstock to assess how the burning of combustible liquid waste as fuel affected the cement manufacturing process. The test burn was also designed to introduce plant employees to all aspects of the waste management process.

Following the successful completion of the preliminary test burn, Lafarge applied for financial assistance from Environment Canada's DRECT program in October, 1982. Approval of financial assistance for an extended test burn was given by Environment Canada in January, 1983 and the following requirements were made of Lafarge:

- design and install a reliable and safe handling and firing system for test purposes;
- investigate process, product and environmental implications of burning liquid wastes as a fuel; and
- depending on the outcome of the test burn, install a full-scale system on a permanent basis.

The 90-day test burn was carried out between October 5 and December 28, 1983 under three temporary permits issued by the Ontario Ministry of the Environment.

Aspects of the Woodstock resource recovery project included in the following report are:

- costs;
- applicability on a national scale;
- environmental implications;
- complete process;
- process used in disseminating information to the public; and
- economic feasibility.

In addition to the above information, this report also includes an update on the current status of the Woodstock project. Reports related to the project are available upon request from Lafarge Canada.*

Environmentally and economically, the use of combustible liquid wastes as supplementary fuel in cement kilns is recognized as one of the best technologies for completely and safely destroying these wastes, while simultaneously recovering their energy value. Extensive monitoring of a 90-day test burn conducted at Woodstock confirmed that no significant increase in emission levels resulted from the burning of combustible wastes. The extremely high combustion temperatures, turbulence and long residence times of the kiln environment ensure the total and safe destruction of the wastes.

Lafarge Canada's principle objective in burning liquid combustible wastes at Woodstock is to reduce manufacturing costs

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* For further information contact R.W. Suderman (519) 423-6241

and therefore maintain the competitiveness of this older generation plant in a market supplied predominantly by newer plants. A permanent resource recovery installation could replace 20% of conventional fuel with 2.0×10^7 L of organic wastes generated by Ontario's industries. While energy prices are low, the fuel cost savings alone do not justify the capital investment of $1 200 000. However, the savings coupled with the expected disposal revenue make the project economically attractive. The long-term fuel savings are expected to be even greater as energy prices increase.

Ontario industry currently pays high disposal charges for its wastes, a major portion of which are exported for reuse or disposal in the United States, with the balance going to landfill or incineration. It is estimated that the use of wastes as supplementary fuel in cement kilns in Ontario and other provinces could provide generators with a more economical waste disposal system.

Lafarge Canada has no doubt that the technology for burning qualified wastes in cement kilns also has applicability on a national scale. Adding facilities to receive, test and store wastes at existing cement plants is much less expensive than building new waste disposal sites.

Other benefits include:

- the strengthening of the Canadian cement industry through a reduction in manufacturing costs;
- the replacement of imported fuels such as coal; and
- a reduction in the need to transport hazardous wastes by permitting a number of cement plant sites to burn hazardous wastes rather than a few incinerators in remote areas.

Section 2

Objectives and Implications of the Woodstock Project

2.1 Objectives

There were two principal objectives in establishing a resource recovery facility at the Woodstock cement plant:

- reduction of manufacturing costs; and
- provision of environmentally sound waste disposal facilities.

Woodstock was selected as one of the plants at which Lafarge wished to burn combustible wastes. It is close to Canada's largest source of liquid industrial wastes and has high production costs associated with the "wet" manufacturing process. The plant is also similar to another Lafarge plant in Paulding, Ohio, which has been successfully burning wastes in its cement kilns since 1979.

a) Reduction of Manufacturing Costs

The cement manufacturing process is energy-intensive, with fuel accounting for 20 to 25% of production costs. The Woodstock plant must reduce its production costs if it is to remain competitive in the Ontario and North American marketplace. Since the plant uses the "wet" manufacturing process, as opposed to the more recent and economical dry process, fuel consumption is high. However, the expense of a conversion from the wet process to the dry process would be prohibitive.

Fuel comprises about 21% of the total cost of cement production at Woodstock. A primary objective of Lafarge Canada Inc. is to reduce energy consumption per tonne of product by seeking alternative fuels to coal and natural gas where it is economically and technically feasible and environmentally sound. The use of combustible liquid waste as a fuel could cut those production costs significantly. By burning waste fuels to recover their energy value, a typical cement kiln could burn approximately 113 500 L of hazardous waste per day to provide about 20% of its heat requirement. Waste fuels typically have a heat value of 25 MJ/kg (11 000 BTU/lb) which is comparable to coal but costs half as much.

b) The Need for Waste Disposal Facilities in Ontario

The demand for waste disposal facilities remains in a state of flux as the scientific community, in both the public and private sectors, probes for answers to increasingly complex waste disposal problems. The Ontario Waste Management Corporation (OWMC) facility, which will serve only about 25% of Ontario's disposal market under full operational load, faces a long and uncertain approval process. The disposal process is currently strained by the limited number of approved disposal facilities operating and a substantial reliance on export to the U.S.

In 1986, Ontario produced an estimated 3.6×10^6 t, or 59% of Canada's hazardous waste, of which approximately 1.0×10^6 t is combustible. This means that Ontario is by far the largest producer of hazardous waste in Canada, as indicated by Figure 1. About 65% of these wastes are treated by the generator, leaving 350 700 t for off-site treatment. Much of this material has potential as kiln fuel.

Due to the high disposal charges for incineration, it is estimated that up to half of the wastes that could be qualified for use at Woodstock are being transported out of the

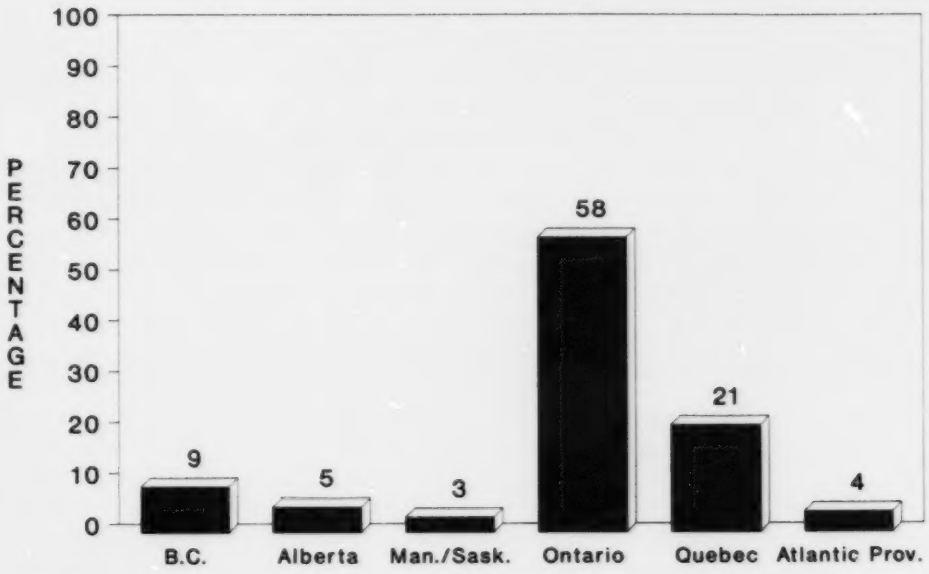

Figure 1 Hazardous Waste Generation by Province (1986)

province for disposal or reuse. The balance is being handled within the province by landfilling or incineration. Using waste as supplementary fuel in cement kilns in Ontario could provide generators with a more economical waste disposal system.

The waste proposed for use in Woodstock's resource recovery facility would be drawn from organic wastes generated in Ontario that require disposal off the generator's site. Highly halogenated wastes, PCBs and pesticides will be excluded. Table 1 provides a list of the estimated quantities of organics which, according to a Fenco Lavalin study, could potentially be used as kiln fuel (Fenco Newfoundland Lavalin, August 1988).

Some material of other classifications may also be suitable for use as a supplementary fuel. The materials received for use at the proposed waste management facility must meet Lafarge fuel specifications or be capable of being blended to meet these specifications. With regard to oily wastes, since there is an economic benefit in their reclamation for reuse as oils, it is not expected that this waste stream would be used as a supplementary fuel.

The disposal facilities currently available to treat Ontario's liquid industrial wastes include landfills, sludge farms, incinerators and out-of-province shipments to treatment and disposal facilities in the U.S. There is no question that Ontario industry needs sound environmental alternatives located within the province to dispose of its waste streams. It is also equally apparent that such alternatives would be able to offer Ontario industry a more cost-effective option to high-cost, special waste incineration which does not have a production benefit.

SYSTECH, the waste management division of Lafarge, undertook a market survey in late 1982 and early 1983. This survey included reviewing published data from the Ontario Ministry of the Environment (MOE) and OWMC, estimates prepared by consultants of waste generation rates in Ontario, and direct contacts with industry and firms in the waste management business. The evaluations

Table 1 Available Organic Fuel*

Waste Classification	Volume (tonnes) Generated in 1986
Organic sludges	36 000
Solvents and organic solutions	99 600
Oils and greases	35 800
Oil/water mixtures	17 800
Organics and oily residuals	161 000
Paint and organic residuals	500
Total	350 700

* Fenco Newfoundland Lavalin (August, 1988).

indicated that sufficient waste is being generated in Ontario to make a waste management facility at Woodstock a sound economic proposition. At peak capacity, the proposed facility at Woodstock could use up to 2.0×10^7 L/yr of liquid organic waste as a supplementary fuel.

2.2 *Applicability of Technology on a National Scale*

Canada currently generates 1.6×10^7 t of municipal waste and 6.1×10^6 t of industrial hazardous waste annually.

The majority of nonhazardous industrial wastes are disposed of on generator sites. Almost 70% of the hazardous wastestream originates from primary industry sources. More than half of these wastes, which are inorganic in nature, contain no recoverable energy and are treated before disposal.

Spent solvents and waste oils constitute 42% of the organic hazardous wastestream in Canada. Due to their high energy content, these wastes are excellent supplementary fuels for cement kilns. However, it is estimated that less than 5% are currently being reused or recycled. This low recovery rate is related to a lack of economic incentive and a regulatory and social ambiance that is frequently hostile to resource recovery projects.

At present, approximately 85% of municipal waste is landfilled, and most of the remainder is incinerated. Unfortunately, many existing landfill sites are reaching capacity and must be replaced. At the same time, popular resistance to this disposal method is mounting. State-of-the-art landfills are capable of handling many types of waste, but an inescapable and undesirable result of landfilling is that the materials are not permanently destroyed. There is also the potential for continuous leachate production which will require additional treatment or disposal technologies. Furthermore, landfilling requires the use of large tracts of land. While viable alternatives to landfill sites are being developed, the use of more stringent environmental legislation will increase the cost of establishing new landfill sites. Higher tipping fees will also be enforced to discourage the use of landfilling. Viable alternative processes have been developed and commercially exploited in Europe, but are only slowly gaining a foothold in Canada.

Waste management in Canada appears to be moving towards the creation of provincial monopolies that are designed to operate a single disposal site. This trend will drive up the cost of waste disposal for the following reasons:

- new facilities are expensive to build;
- transportation costs to remote locations are high;
- existing facilities would not be used; and
- disposal charges would not be based on competition.

This trend also denies the energy-intensive cement industry the opportunity of using these wastes as a means of reducing manufacturing cost, while also providing an economically and environmentally sound disposal system.

The Canadian cement industry has an annual production capacity of 1.6×10^7 t of cement. Eight companies operate plants and terminals in all provinces. The industry has reduced its fuel costs by 25% since 1974, partly through better equipment and partly by switching to cheaper fuels and achieving fuel flexibility. The next round of reduction in energy costs will come from replacing the primary energy sources, such as coal, gas and oil, with waste-derived fuels.

In 1987, the Canadian cement industry produced 1.0×10^7 t of cement. If 40% of its fuel had been waste-derived, 720 000 t or 65% of all the organic industrial waste generated in Canada could have been recycled as kiln fuel.

In the case of refuse-derived fuel (RDF) from municipal waste, a cement plant with one million tonnes capacity could, by replacing 15% of its fuel, burn about 36 000 t of RDF per year. This quantity of RDF would come from processing 60 000 t of municipal waste, which is the amount generated by a city of about 85 000 inhabitants.

While cement kilns can safely destroy most industrial liquid and solid wastes, the most commonly used waste-derived fuels in U.S. and European cement plants are spent organic solvents from a range of industries, such as paint and coatings, pharmaceuticals, cosmetics and electronics. Other types of wastes being used or tested include RDF from municipal wastes, spent potlinings from the aluminum industry, tires, wood wastes, carbon fines, flax shives and shredder fluff from automobile demolition. Public opposition has acted as a deterrent to the burning of such high profile hazardous wastes as polychlorinated biphenyls (PCBs) despite the fact that test burns demonstrate the ability of cement kilns to destroy these substances.

While properly designed hazardous waste incinerators can also destroy virtually 100% of all types of organic wastes, current commercial incineration capacity is limited and new sites are expensive to build. Adding facilities to receive, test and store wastes at an existing cement plant is a far less expensive proposition. The environmental and economic benefits of burning and destroying wastes in the existing national network of cement plants could result in this disposal option becoming an integral part of the waste management strategy for all provinces.

The cement industry, as part of the private sector, should operate as safely and responsibly as the public sector when burning wastes as supplementary fuels in cement kilns. The industry has an obligation to safeguard the health of employees and the public at large. This sense of responsibility, which is complemented by environmental legislation, will ensure the safe operation of waste management facilities at cement plants.

2.3 Costs and Economic Feasibility

The cement manufacturing process is energy-intensive with fuel accounting for 20 to 25% of manufacturing costs. In 1987, the industry, in producing 1.0×10^7 t of clinker, used 4.4×10^7 GJ of thermal energy, which is equivalent to the energy from 1.6×10^6 t of coal. The industry's use of energy, in response to changing economic conditions, has evolved along two complementary lines. The first is improvement of energy efficiency, which has been partly achieved by installing

new technically advanced plants in place of older ones, and partly by modification of existing equipment. Between 1974 and 1987, the average energy required to produce a tonne of cement was reduced from 6.2 to 4.8 GJ - an improvement of 25%. At the same time, fuel efficiency improved from 5.7 to 4.3 GJ/t as shown in Figure 2.

The second approach to changing economic conditions has been to switch to cheaper fuels. As the bar chart in Figure 3 indicates, the use of oil between 1974 and 1987 dropped from 39% of heat input to 2% after being replaced by coal. Natural gas as a percentage of fuel fell between 1974 and 1986 from 49 to 24%, but increased to 31% of fuel requirements in 1987 when gas prices became more competitive with coal in British Columbia. Most cement plants have made the capital investment necessary to achieve fuel flexibility and can select energy sources according to cost. Progress along these lines has been most successful, but will probably show diminishing returns in the future in the area of fuel efficiency. The next round of reductions in energy cost will come from replacing the primary energy sources of coal, gas and oil with waste-derived fuels.

Woodstock is a wet-process plant with a fuel efficiency of over 5 GJ/t of clinker. It uses coal from the United States, domestic or imported coke and natural gas. The pie chart in Figure 4 illustrates what percentage of each fuel source is required to meet current energy requirements.

Due to the general drop in energy prices and Woodstock's flexibility in choosing fuels, fuel costs have declined to 17 to 20% of cement manufacturing costs in recent years, compared to a 29 to 30% range in 1980 and 1981. This trend is graphically presented in Figure 5.

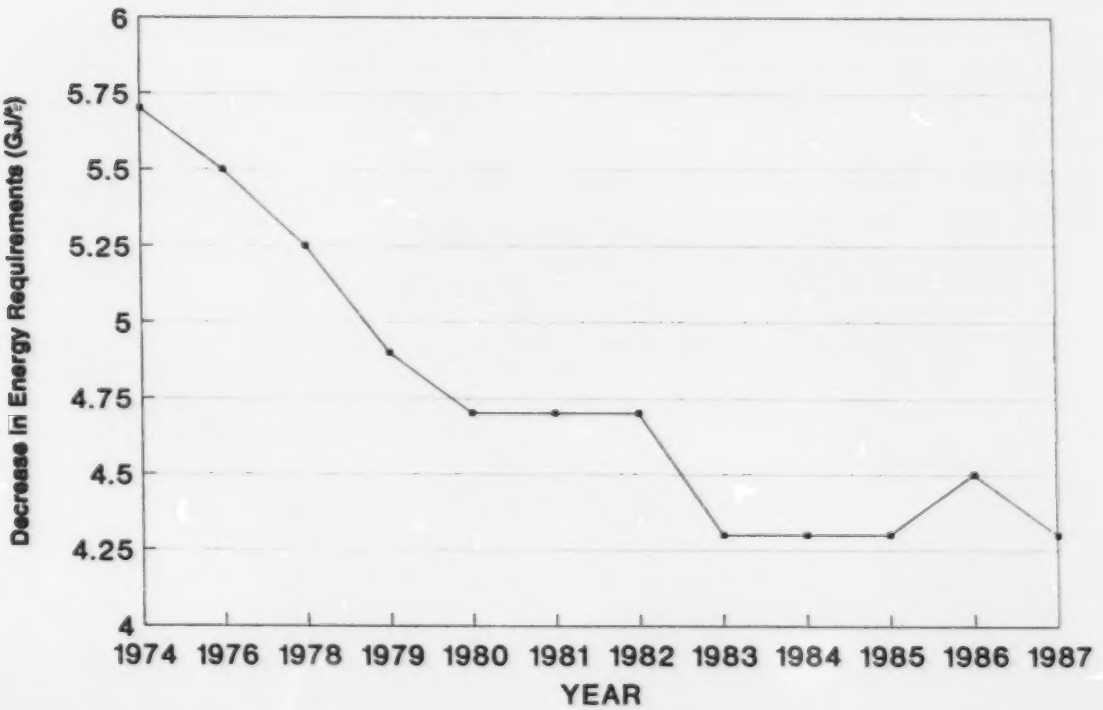

Figure 2 Fuel Efficiency Improvements since 1974

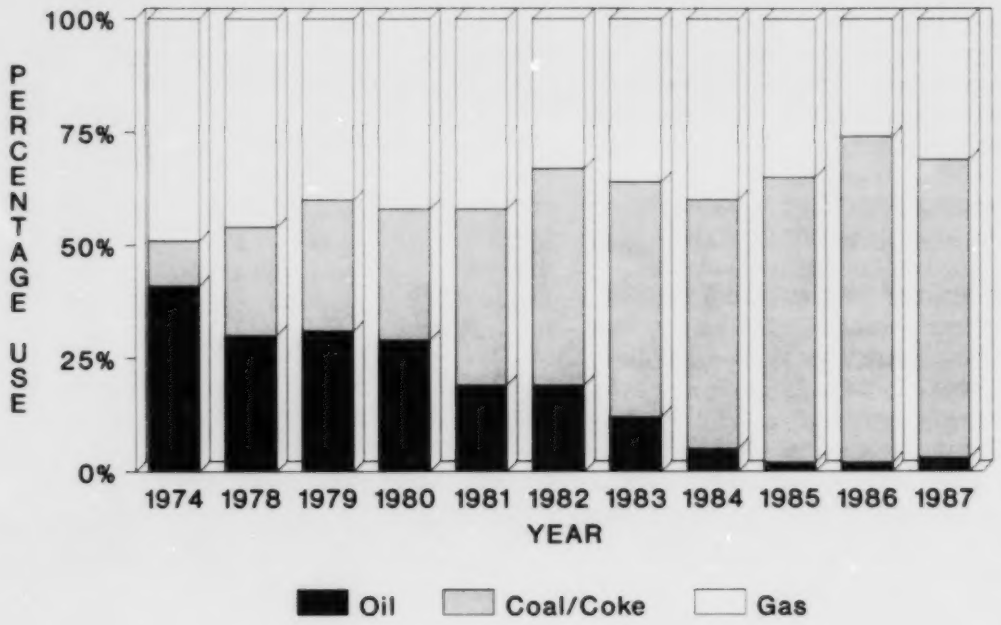

Figure 3 **The Use of Coal and Coke as Principal Fuels in Cement Production**

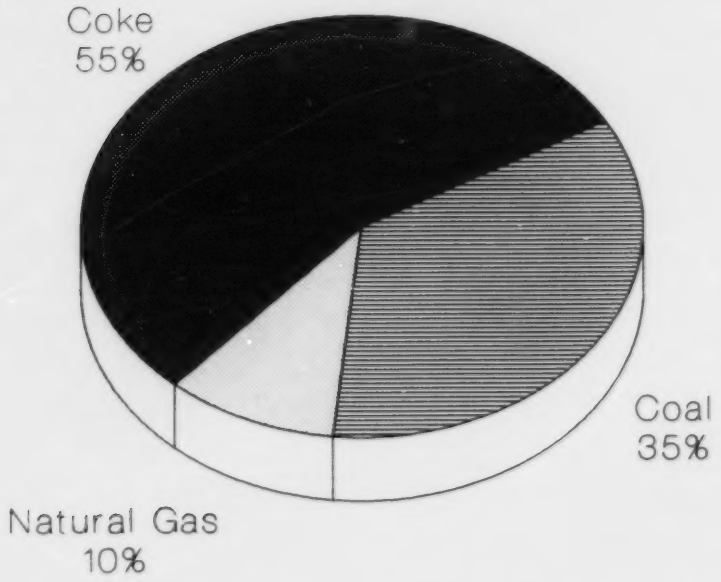

Figure 4 **Fuel Mix at Woodstock Cement Manufacturing Plant**

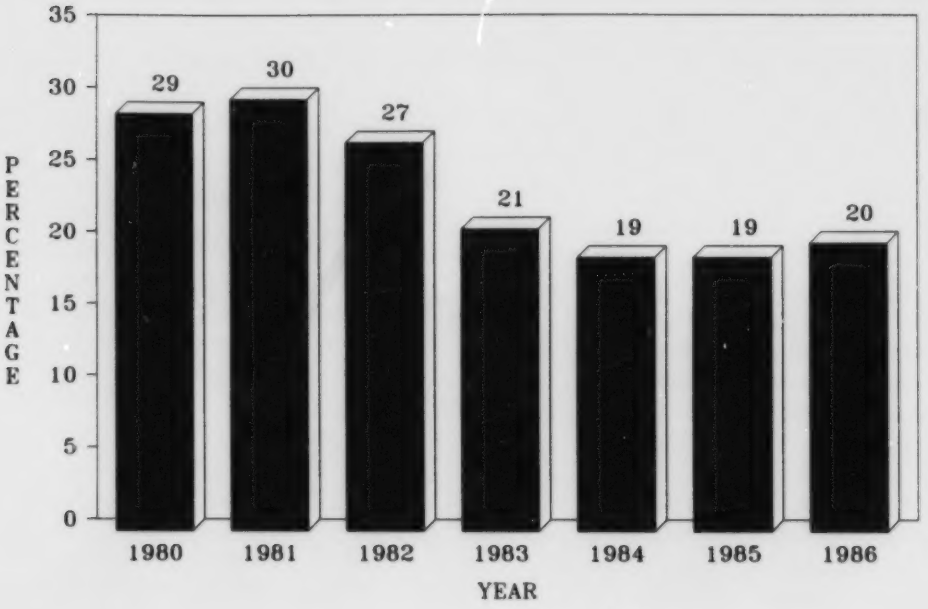

Figure 5 Fuel as a Percentage of Manufacturing Costs at Woodstock

Burning organic liquid wastes offers the plant a technically and environmentally sound means of achieving a major reduction in manufacturing costs, thus maintaining the competitiveness of this older generation plant in a market supplied predominantly by newer plants.

The objective is to replace about 20% of conventional fuel with 2×10^7 L of organic wastes drawn from industries in Ontario. While a specific supply contract for waste-derived fuel has not been drafted, the basis of discussion was:

- that Woodstock should install and pay for the waste storage and firing system;
- that the supplier was to provide the testing laboratory;
- that Woodstock would purchase the waste-derived fuel at 50% of the average cost of conventional fuels; and
- that Woodstock would receive 50% of net disposal revenue (disposal fee charged to generator, less transportation cost to plant site).

A waste-handling installation consisting of a truck-receiving station and four 110 000-L storage tanks in a concrete containment basin was estimated to cost $1 200 000. The assumptions in Table 2 were used to calculate a return on this investment, using 1987 fuel costs rather than those of 1982 when the project was initiated. During the period of low energy prices, the fuel cost savings alone did not justify the capital investment. However, when the shared disposal revenue was included, the project was economically attractive.

Table 2 Estimated Return on Investment from Waste-derived Fuel Incineration

Cost Factors	Totals
• Capital investment	$1 200 000
• Project development, including public information program and hearing	$500 000
• Litres of waste burned per year	2.0×10^7 L
• Net disposal revenue	$0.04/L
• Fuel replacement by waste	20%
• Fuel cost saving per year	$345 000
• Fuel cost saving per tonne of clinker	$0.69

Capital outlay and annual revenue streams were summarized as follows:

Capital	$1 700 000
Fuel Savings	$345 000
Disposal revenue	$400 000

From these figures, return on investment could be calculated as follows:

Internal Rate of Return	20%
Payback period	4.2 years
Net Present Value at 15%	$283 698

Section 3

The Cement Manufacturing Process

3.1 Composition of Cement

"Cement is the flour, concrete is the cake" is an old saying among cement workers. Cement is the dry powder that results from a process involving extreme heat and actual chemical change. Concrete, on the other hand, is a mixture of sand, aggregate, water and cement, in which cement acts as a binder. Practically all the mortar and concrete seen in this country is derived from Portland cement which is manufactured in Canada. Portland cement is strictly controlled as to its composition and quality by the Canadian Standards Association (CSA) and the American Society for Testing and Materials (ASTM). When it has set, it is the hydration product of a number of inorganic compounds which are listed in Table 3.

Limestone is quarried on the Woodstock plant property and transported to the cement plant by conveyor belt. It is crushed by first passing the rock through a gyratory crusher and then an impactor. The crushed rock is then carried on belts to a stockpile for later use. When required, it is drawn from the stockpile and conveyed to large ball mills. Fly ash is another ingredient used in the cement production process. The fly ash is a waste product of thermal generating plants. It is the ash that remains after the coal is burned. A finely divided powder, it is collected by electrostatic precipitators or other particulate emission control devices in the power plant. It is delivered to the plant via truck transport. Currently, Ontario Hydro is the principal supplier, but other plants have been used in the past and could serve as fly ash sources in the future.

Table 3 Chemical Contents of Portland Cement

Name of Chemical	Chemical Formula	Abbreviation	Percent of Dry Content
tetracalcium aluminoferrite	$4CaO \cdot Al_2O_3 \cdot Fe_2O_3$	C_4AF	11%
tricalcium silicate	$3CaO \cdot SiO_2$	C_3S	50%
dicalcium silicate	$2CaO \cdot SiO_2$	C_2S	28%
calcium sulphate	$CaSO_4$	$CaSO_4$	3%
tricalcium aluminate	$3CaO \cdot Al_2O_3$	C_3A	8%

From the foregoing it follows that raw materials used to produce Portland cement must contain or produce lime (CaO), alumina (Al_2O_3), iron oxide (Fe_2O_3) and silica (SiO_2). Calcium sulphate can be added later in the form of gypsum. At Woodstock, cement is manufactured from limestone (as a source of calcium), fly ash (rich in alumina and silica), and iron oxide. The Woodstock flow schematic for the wet process is shown in Figure 6 and explained in the following text.

3.2 The Wet Process

Handling the raw mix in water suspension is characteristic of the "wet" process for cement manufacture. By contrast, the "dry" process uses only dried powdered materials. In the wet process, raw materials are fed to the kiln in a slurry form which contains about 32% water. In order to evaporate this water from the kiln feed, it must pass through a dehydration zone within the wet-process kiln.

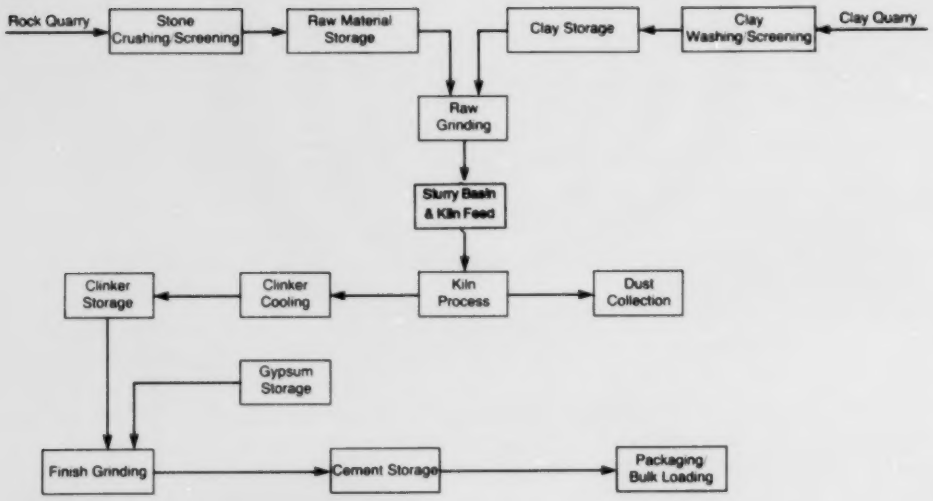

Figure 6 Woodstock Material Flow Schematic for the Wet Process

A dry-process kiln of the same diameter has no need for this zone. To produce an equivalent amount of product, a wet-process kiln requires significantly more fuel than a dry-process kiln because of the extra heat required to evaporate the water. From the standpoint of the energy-from-waste program, the most significant aspect of the wet process is that the higher moisture content of the wet material increases the heat requirement by about 33% above the requirement of the dry process.

Before being directed into the kiln, the slurry is pumped into storage tanks and is agitated to prevent settling. Slurry samples are taken and analyzed on a bi-hourly basis to ensure the quality of the future cement. The next stage in the process involves firing the slurry in a rotary kiln which is lined with refractory brick. The wet-process kiln depicted in Figure 7 is 3.7 m in diameter and 137 m in length. There is a chain section for heat transfer at the high end of the kiln where the raw mix slurry material is introduced. The kilns are inclined on a slope of 3.75 cm/m which causes the material to flow downwards as the kiln revolves. The fuel mix used at Woodstock consists of a mixture of two-thirds petroleum coke and one-third coal. Natural gas is burned in small quantities as a supplementary fuel to control the flame length. The solid fuels are pulverized in a ball mill and then blown into the kiln through a burner pipe with air.

In the kiln process, the slurry is pumped to feeders above the kilns which cause a constant volume to run by gravity into the feed end of the kiln. It advances counter-current to the hot gases through the chain section, which is about 18.3 m in length, where the water is driven off. Further down the kiln, where the temperatures are approximately 870°C (1600°F), carbon dioxide is released from the calcium carbonates which results in the formation of calcium oxide (lime). This area is called the "calcining zone". Below this zone is the "burning zone", where the kiln temperatures are in the range of 1427 to 1649°C (2600 to 3000°F). It is in the burning zone where iron, alumina flux, lime and silica react to form clinker. Note that the temperatures quoted

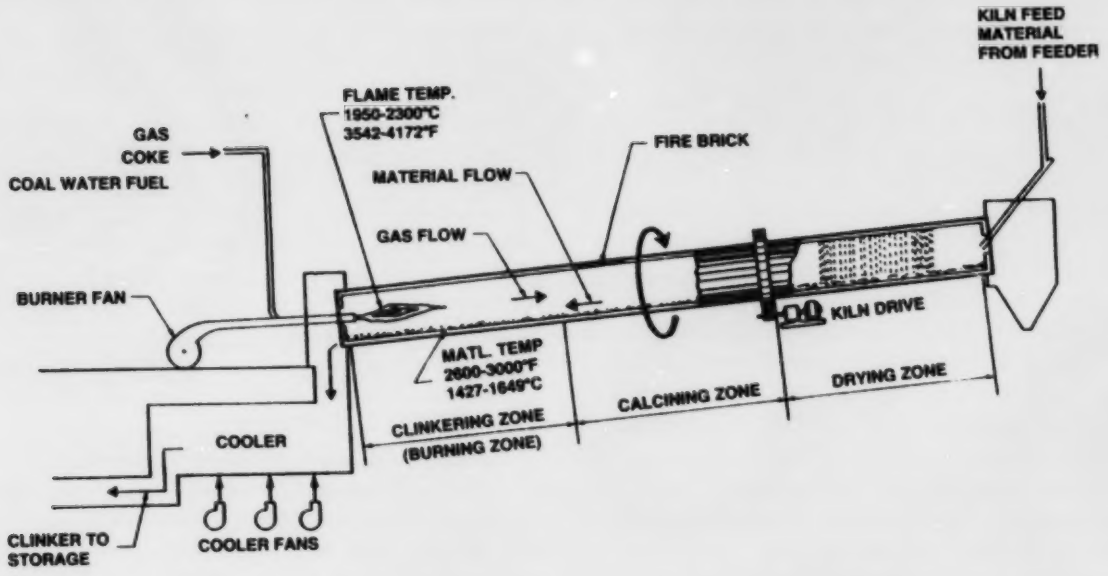

Figure 7 Raw Material Burning in the Wet-Process Kiln

here are the temperatures of the solid material in the kiln.

Cement is made from the clinker after cooling. The clinker, in the form of many rough, dark grey spheres, generally 2.5 cm or less in diameter, is discharged from the kiln into a clinker cooler where large fans cool the material quickly to approximately 65°C (150°F). The clinker is then either stored or transported to the finishing mill where it is ground and pulverized with gypsum to the point that 90% of the material will pass through a 325-mesh-per-inch sieve. The resultant greyish-white powder is known as Portland cement.

3.3 Quality Control

Chemical and physical controls are very important in the production of cement. Frequent and regular analysis of raw materials, slurry mixes, clinker and finished cement is essential. This chemical and physical control is carried out in the plant laboratory which is staffed by the Chief Chemist, Assistant Chemist, Analyst and six other employees who perform scientific tests on raw materials and finished products. The results of this analytical process are used to direct the Production Department in its selection of the quantity and type of raw materials to be used in cement production. At the various intermediate stages in the production of cement (stone, slurry, clinker, cement), the Lafarge laboratory provides analytical services to ensure that the desired chemical and physical properties of the finished cement product will be met.

3.4 The Combustion Process

The heat required for the successful operation of a rotary kiln is obtained by the combustion of fossil fuel. To obtain optimum combustion, three conditions must be fulfilled:

1. sufficient oxygen must be available to combine chemically with the fuel;
2. a high enough temperature must be maintained to ignite the fuel-oxygen mixture; and
3. sufficient turbulence must be provided to ensure that the fuel and oxygen mix

under adequate temperature conditions, thereby achieving the high combustion efficiency desired.

The oxygen required to complete combustion is provided from three sources: the primary and secondary air supply systems, which are operator-adjusted to suit burning conditions within the kiln, and air in-leakage. The ambient air is drawn into the kiln via openings around the mating faces of the moving and stationary parts of the kiln (air drawn in by negative pressure within the kiln). Primary air represents about 10% of the total air supplied, and this is injected into the kiln with the fuel. Primary air is usually at ambient temperature. Secondary air is typically 85% of the total air supplied, and is delivered via the clinker cooler. Secondary air is hot, being between 600 and 800°C (1112 to 1472°F). Infiltration is of course at ambient temperature, and accounts for the remaining 5% of the total air supply.

For fuels commonly used in cement kilns (coal or coke, Bunker "C" oil, and natural gas), the flame temperature is calculated to be in the range of 1950 to 2300°C (3542 to 4172°F). The actual temperatures are somewhat lower because heat is transferred to the load (raw materials) and to the surrounding flue gas and kiln walls before the heat release process can be completed. The actual temperature within the flame with a secondary air temperature of 800°C (1472°F) and an excess oxygen level of 2% is about 2000°C (3632°F).

From the standpoint of burning liquid waste in the kiln, it is worth noting that very few if any organic materials can withstand temperatures exceeding 1200°C (2200°F). Organic compounds can be efficiently decomposed into their elemental constituents at these high temperatures (most at lower temperatures). Therefore, the high-temperature conditions which inherently exist in the burning and calcining zones of a cement kiln provide extremely good conditions for the complete destruction of fossil fuels. For comparison purposes, for efficient burning of most solid and liquid wastes, conventional waste incinerator designs call for temperatures in the range of 750 to 980°C (1400 to 1800°F) for one-half to one second retention in the primary chamber, with temperatures rising to the 1000 to 1100°C range in the secondary chamber. The more difficult to destroy chlorinated organics, such as PCBs and dioxin, require temperatures up to 1200°C (2200°F), and residence times up to two seconds.

The Woodstock plant presently uses a fuel mixture of 62% petroleum coke, 31% coal and 7% natural gas. The quantities of combustion gases that result from this mixture are listed in Table 4.

The burning zone where the cement compounds are produced is approximately 27.4 m (90 ft) in length. The average gas temperature in the burning zone is approximately 1700°C (3092°F). At this average temperature, the combustion gases have a theoretical volumetric flow rate of 428 091.5 am^3/h (actual cubic metres per hour). The kiln diameter in the burning zone is 3.66 m (12 ft). Subtracting 0.46 m (18 in.) for brick, 0.15 m (6 in.) for "coating" and assuming an 8.5% kiln load, the effective cross-sectional area is calculated to be approximately 4.28 m^2 (46.1 sq ft). Thus, the theoretical gas velocity in the burning zone is 27.78 m/s (91 fps). The calculated residence time of the gases in this zone is 1 s, so the fuels pass through the burning zone under gas temperatures of 1700°C for 1 s.

The gas temperature decreases as the transition from the burning zone to the calcining zone occurs. Carbon dioxide is added to the exhaust gases throughout the calcining zone at a rate of 9522 Nm^3/h. The average temperature of the gases in the calcining zone is approximately 1300°C (2372°F) and the length of the zone is approximately 61 m. Adding the quantity of carbon dioxide evolved, and calculating the

Table 4 Quantities of Gases Resulting from Kiln Combustion* (normal m^3)

Gases and Vapours	Volume		
Nitrogen	42 426.8	Nm^3/h	(1455 Nm^3/t)
Carbon Dioxide	8 982.2	Nm^3/h	(308 Nm^3/t)
Water Vapour	6 524.8	Nm^3/h	(224 Nm^3/t)
Sulphur Dioxide	92.05	Nm^3/h	(3.2 Nm^3/t)
Excess Oxygen	1 208.3	Nm^3/h	(41 Nm^3/t)
Total	59 234.15	Nm^3/h	(2031 Nm^3/t)

* Figures based on a kiln production rate of 700 t/d.

average volumetric flow rate at 1300°C, yields a flow rate of 396 164.4 am^3/h in the calcining zone of the Woodstock kilns. The effective cross-sectional area here is 4.82 m^2 (51.9 sq ft), assuming a 0.08-m (3 in.) coating. Thus, the velocity is 22.83 m/s (75 fps), providing a calcining zone gas residence time of 2.67 s. Therefore, the total residence time in the kiln at temperatures exceeding 1093°C (2000°F) is approximately 3.67 s. This means that cement kilns provide longer residence times and higher temperatures than those specified for hazardous waste incinerators by the *Environmental Protection Act*. The total residence time of gases in the kiln is 5.98 s if the drying zone is included as part of the total residence time. The average temperature in this zone is 650°C (1202°F) and it is approximately 48 m (160 ft) long. Since these temperatures are lower than conventional incinerator outlet temperatures, the drying zone is not expected to contribute significantly to the burning efficiency of the kiln.

The general configuration of the kiln in relation to the other components of the Woodstock facility is featured in Figure 8. Figure 8 also points out the approximate temperatures of the kiln at various points along its length.

The comparatively long gas residence times demonstrated in the cement kiln result from requirements developed solely for the cement manufacturing process. It is coincidental that the gas temperatures and residence times necessary in the burning and calcining zones to achieve cement production are substantially higher than those typically required for hazardous waste incinerators and conventional waste incinerators.

3.5 Rotary Cement Kiln Scrubbing Action

An inherent benefit of the rotary cement kiln is its dry scrubbing action. Within the kiln, concentrations of acid gases, such as sulphur dioxide, are reduced when these gases come into contact with alkaline solids. Thus, if waste fuels containing chlorides are burned, the amount of chlorides escaping to the atmosphere will be reduced. In addition, if chlorinated wastes are burned, they tend to react with the sodium and potassium compounds in the clinker to form sodium and potassium chlorides. These two compounds volatilize in the kiln and are carried off in the flue gas. Ultimately they condense in the cooler drying zone of the kiln to become a particulate which is collectable by the electrostatic precipitator. This particulate is later returned to the production system as raw material feed for the kiln.

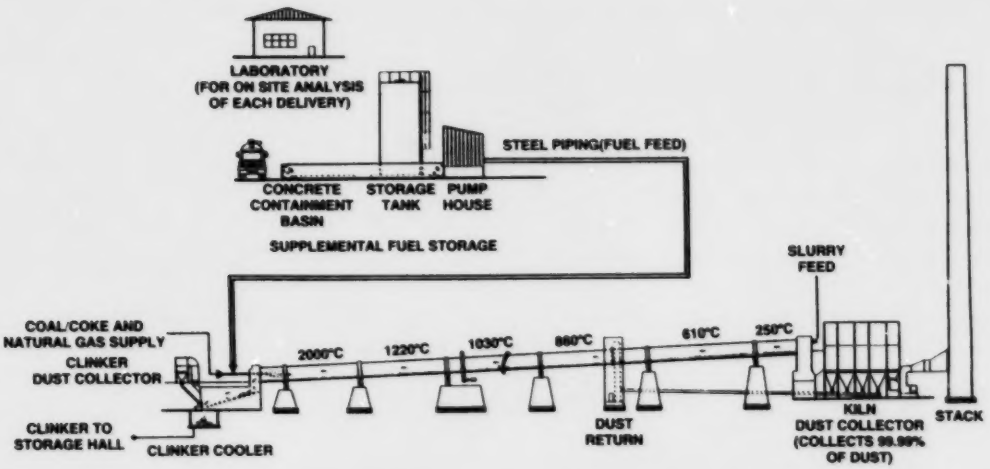

Figure 8 Primary Components of the Woodstock Kiln and Supplemental Fuel Supply

3.6 Use of Waste-derived Fuels at Other Sites

When Canada Cement Lafarge acquired Dallas-based General Portland Inc. (GPI) in 1981, the U.S. company was using and continues to use combustible liquid waste as an energy source. General Portland had been burning these liquids since 1979.

In June of 1982, Lafarge representatives visited the GPI cement plant at Paulding, Ohio, to view the operation of the combustible liquid waste fuel facility located there. It was during this period that Lafarge first became acquainted with SYSTECH Corporation, the waste management firm supplying Paulding with this fuel. SYSTECH became part of the Lafarge group of companies late in 1986, so that an integrated approach could be developed for more widespread application of the supplementary fuel program. From a technical standpoint, the similarities between the Paulding and Woodstock plants are substantial. Both plants use the wet process for cement manufacturing with equipment of similar age and capacity. They also produce similar product lines.

Due to the initial success at Paulding, Lafarge and SYSTECH are currently using combustible liquid waste as fuel at the following plant locations: Alphena, Michigan, Fredonia, Kansas, and Demopolis, Alabama. SYSTECH also operates facilities at Los Robles, California (a former Lafarge plant now owned by National Cement) and at the Lone Star Cement plant in Greencastle, Indiana. Several other plants are seeking permits to burn combustible liquid waste as well.

In the course of studying the proposal to burn liquid industrial wastes as supplementary fuel, both management and union delegates from the Woodstock plant visited the Paulding facility. Their intention was to assess the burning compatibility, occupational health and safety, product quality and market implications, and equipment maintenance. Having discussed the project with General Portland personnel and studied available literature, it was concluded that the operations were viable and environmentally sound.

A separate market survey for combustible liquid waste generators in Ontario was then undertaken by SYSTECH. As a result of this preliminary work, it became apparent to Lafarge that a similar project could be implemented at the Woodstock plant. Combustible liquid waste has also been

successfully burned in Scandinavian cement kilns. Although some of the available literature was reviewed by Lafarge personnel, it was decided to visit the plants in person.

The environmental managers of both Canada Cement Lafarge and General Portland facilities traveled to Europe in June 1983 to meet with representatives of Cementa in Sweden and Norcem in Norway. They also met with members of the Swedish Institute of Air and Water Pollutions Research (IVL). They reviewed test results available from waste disposal tests in incinerator and rotary cement kilns. The research conducted by IVL and Cementa demonstrated that there is typically no significant change in emissions when combustible liquid waste is burned.

Extensive testing carried out since 1983 in the U.S., Canada, Europe and other countries continues to prove that burning of wastes as supplementary fuels in cement kilns is a safe and reliable technology. The tests also verify that these kilns achieve destruction and removal efficiencies equal to those achieved by the best hazardous waste incinerators.

Section 4

Fuel Procurement, Transportation, and Storage Program

Before conducting the test burn programs at the Woodstock plant, it was important to establish a source for the type of liquid waste that could be safely disposed of in the cement kiln. To meet this objective, a program had to be established to evaluate the contents of incoming liquid waste. At the same time, it was necessary to carefully assess the transportation and storage of the liquid waste. This section outlines the steps that were undertaken by SYSTECH to deal with these matters.

4.1 Fuel Procurement

Fuel procurement refers to the purchase of combustible liquid waste from industry for use as a fuel in making cement at the Woodstock plant. The following major tasks are involved in the waste fuel procurement sequence before fuel within this special classification could be incinerated by Lafarge:

- generator qualification;
- transportation;
- on-site receipt;
- tank farm operation; and
- fuel tendering.

It was proposed that the fuel procurement aspect be handled by SYSTECH, using their specialized experience in the management of liquid industrial wastes. SYSTECH would procure combustible liquid waste that met or could be blended to meet the Lafarge fuel specification shown in Table 5. This fuel specification would be submitted to the MOE as part of the *Environmental Protection Act* Part V application for approval of the waste management program and as a condition to the Section 8 application. All waste generators would be classified under Regulation 309 and the provisional waybill system would be followed in its entirety. The fuel burning aspect of the process refers to the use of combustible liquid waste that has been procured as fuel to partially replace the heat requirement normally supplied by conventional fuels.

Before SYSTECH could provide alternative waste disposal methods for generators of combustible liquid waste, the staff at the generator site were required to complete a detailed questionnaire. This questionnaire provided SYSTECH with information on the types of waste generated and the method by which they were produced. A representative sample of the waste produced at the generator was then provided for use at the Woodstock plant. This representative sample was then analyzed at the Woodstock plant in the fuel laboratory. This facility was operated by SYSTECH independently of the Lafarge plant laboratory operation. The fuel laboratory analysis of the wastestream was routinely compared with all the parameters of the supplementary fuel specification as approved by the MOE.

If the generator's wastestream met the fuel specification or was blended to meet the fuel specification, then the generator was considered to be qualified. The MOE was also advised so that the supporting waybill and manifest could be tracked. The questionnaire and the results of the analysis performed were kept on file and compared with the laboratory analyses performed by SYSTECH on incoming shipments to the Woodstock plant. This procedure was required to verify that the generator continued to send essentially the same material that was originally qualified. Material not meeting the analyses was rejected and the MOE was

Table 5 Fuel Specifications

Heat	- 14 to 46 MJ/kg
Viscosity	- less than 300 centipoise
Odour	- characteristic of solvents (ASTM, D 1296-69)
Suspended solids	- 30% maximum
Sulphur	- 3% maximum
Nitrogen	- 1% maximum
Halogens	- 5% maximum
Inorganic acids and bases	- extractable pH of 4 to 11
Water	- 1% maximum as separated phase
Ash content	- 7% maximum
Heavy metals	- 4000 mg/L lead - 3000 mg/L barium - 3000 mg/L chromium - 3000 mg/L zinc
PCB	- No detectable levels*
Benzene	- 0.5%

* As indicated by SYSTECH laboratory equipment.

advised immediately so that an alternative disposal system could be identified.

4.2 Transportation

Each generator's wastestream was transferred to the Woodstock plant by highway tanker trucks. Generally these trucks had a 23 000- to 36 000-L capacity. All haulers of waste to the Lafarge Plant were independent of Lafarge or SYSTECH and could be licensed by the Province of Ontario for the haulage of hazardous wastes.

The transportation was performed by one of the following methods:

- SYSTECH could contract with a licensed liquid-industrial-waste hauler to deliver the material;
- the generator of the material could in fact also be a licensed liquid-industrial-waste hauler and therefore able to handle delivery; and

- the generator personnel could contract a licensed liquid-industrial-waste hauler of their own choice to handle delivery.

Regardless of the method used to transfer the material, the following information was verified before any delivery arrangements were made.

- The liquid-industrial-waste hauler had to have a valid Public Commercial Vehicle license* for liquid industrial-waste haulage (unless the generator transported its own material).
- The liquid-industrial-waste hauler was required to have a valid MOE permit to haul liquid industrial waste.
- It was necessary for the liquid-industrial-waste hauler to use and abide by the MOE waybill system, Regulation 313 of the *Environmental Protection Act*.
- The liquid-industrial-waste hauler was required to maintain insurance policies for automobile, workers' compensation and general liability.

During the extended test burn, 50 truckloads of liquid industrial waste were delivered to the plant under the SYSTECH program. It was expected that a maximum of eight trucks could be received in a 16-hour working day with the establishment of a permanent facility. However, it is not expected that this maximum receiving figure can be sustained for a full five-day working week.

The transportation of liquid waste to the Woodstock plant was by existing transportation routes. The trucks involved used Highway 401, east and west from Interchange No. 222 (Embro-Foldens) as the major artery with connections made at Highway 402 for the Sarnia area and at Highway 53 and Highway 2 for the Hamilton and the Golden Horseshoe Region. Local access to the plant was attained from Oxford County Road 6 and Highway 2.

4.3 Fuel Acceptance Process

As each tank truck arrived at the plant, it was identified according to its source, checked against the computer data file on generators, weighed in and then directed to a holding area in advance of the off-loading zone at the storage area. A technical representative of the SYSTECH organization met each truck at the holding area, inspected it for general condition, such as leaks or faulty equipment, and took a composite sample of the tank contents. The composite sample was then split, with one half being kept for 90 days for quality assurance checks and the other used to perform the waste shipment analysis at SYSTECH's fuel laboratory at Woodstock. The truck was not allowed to offload until the waste shipment analysis was approved.

Up until the time of acceptance, the generator is considered to be the owner of the waste. Before any waste was accepted at the site, the waste qualification analysis had to be compared with the waste shipment analysis to verify that the generator sent material representative of the original wastestream, qualified and approved by Lafarge and the MOE as meeting the fuel specification.

The shipment was rejected if the waste shipment analysis indicated that:

- the shipment failed to meet the fuel specification and could not be blended with other material to meet the specification;
- the shipment contained detectable PCBs; and

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* This license has since been replaced by provisions in the *Truck Transportation Act*, July 1990.

- the shipment contained regulated substances above the receiving limit levels.

In the case of a rejection, the ownership of the waste would not be transferred. SYSTECH would then inform the generator of the rejection and indicate that the load had to be returned to them. At the same time, the MOE would be notified of the rejection and the reason for it. The number of loads rejected by SYSTECH during the extended test burn at the Woodstock plant represented 12.3% of the loads delivered. It is anticipated that the number of loads rejected in a full-scale operation would normally be much lower; in the order of 3% as a result of greater familiarity with the system on the part of the waste generators. Individual loads and their reasons for rejection during the extended test burn are tabulated in Table 6.

4.4 Tank Farm Operation

The storage area for the wastes at the Woodstock plant, also called the "tank farm", consists of a concrete containment basin and two 65 000-L steel fixed-roof tanks with associated piping and valving. The basin is capable of containing 150% of the contents of four 65 000-L tanks, should all tanks leak at the same time. During the extended test burn, and for economic reasons, only two tanks were erected in the basin. The proposal for the permanent facility would involve increasing the size of the containment basin to accept a total of ten 65 000-L steel fixed-roof tanks. The tank farm and related equipment would all be owned by Lafarge.

Once the combustible liquid waste was accepted by SYSTECH, the load was pumped from the truck to one of the storage tanks with the truck's on-board pump. As the waste stream was pumped into the tank, it was strained of solid particles greater in diameter than 0.32 cm. Any solid material strained out of the waste was then disposed of in the plant's licensed waste disposal facility.

When a tank of fuel had been screened for use, the Lafarge production engineer, process engineer or plant chemist would accept the tank and place a tag on the discharge valve of the accepted tank indicating that the fuel was ready for use. If there was no tag on the discharge valve, the tank would not be used. The particular tank used to contain liquid waste deliveries was determined by the SYSTECH laboratory technician and reflected the fuel specification requirements. In order to meet the Lafarge fuel specifications, SYSTECH is normally required to blend a number of truckloads that would not necessarily meet all the fuel specifications by themselves. Ultimately SYSTECH was required to provide a 65 000-L tank of fuel to Lafarge which was blended entirely to meet the fuel specification.

Table 6 Liquid Waste Fuel Rejected during the Extended Test Burn

Date	Reason for Rejection
September 16, 1983	5000 ppm lead
September 17, 1983	5000 ppm lead
October 27, 1983	PCBs present
November 2, 1983	1625 centipoise
December 2, 1983	PCBs present
December 2, 1983	4.0% chlorine
December 16, 1983	60% solids, 1300 centipoise

4.5 Fuel Tendering

Once a storage tank was full, SYSTECH drew a sample and analyzed it. Half of the sample was kept for 90 days for quality assurance checks if required, and the other half was subjected to the fuel analysis in SYSTECH's fuel laboratory at the Woodstock plant. The fuel analysis would identify and quantify all parameters listed in the fuel specification. These results were then recorded on a tank document record which would be available for review and submission to the MOE. There were 23 tanks screened by SYSTECH during the 90-day test burn.

If the contents of a particular storage tank did not meet the fuel specification through blending, SYSTECH would have removed the contents of the tank and transferred them by highway tank truck to an alternative disposal site. Should such a transfer be required, the provisions of Regulation 309 would be followed. During the extended test burn at the Woodstock plant, no storage tanks were rejected. SYSTECH's records at U.S. plants show that this has never occurred in 20 years of collective operating experience. Once a tank of material was accepted for use as fuel, no further material was put into that particular storage tank until it had been emptied. At this point, the procurement sequence was repeated by refilling the emptied tank. A flowchart which outlines the entire sequence of fuel procurement, assessment and storage is shown in Figure 9.

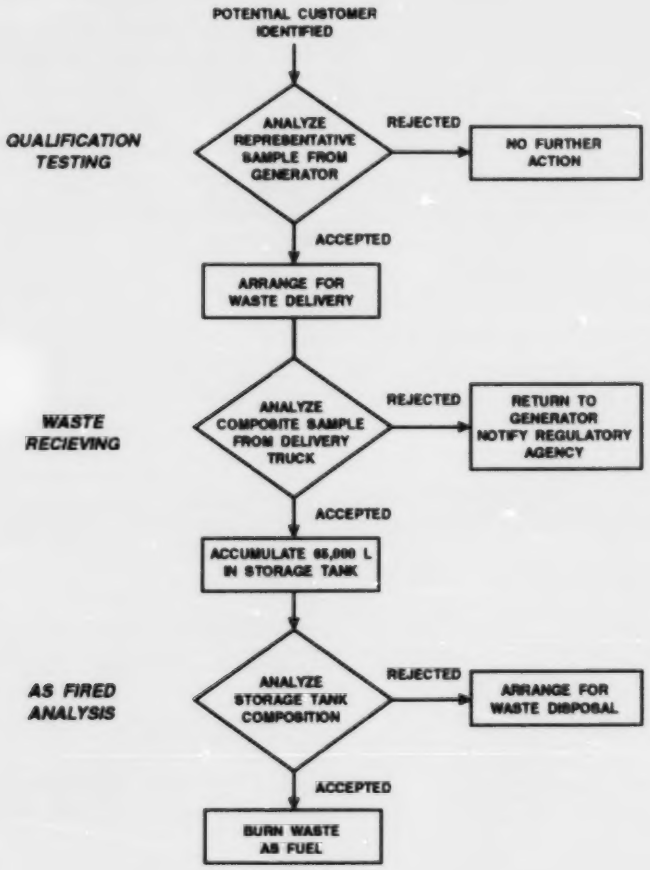

Figure 9 Supplemental Fuels Quality Control Procedures

Section 5

Preliminary Test Burn

The preliminary test burn was a necessity from the standpoint of assessing the effects of burning combustible liquid waste as fuel on the Woodstock plant cement manufacturing process. It also introduced plant personnel to the use of combustible liquid waste as fuel.

5.1 Equipment

Through the investigation of Paulding's permanent burn facility, equipment for the Woodstock preliminary burn facility was chosen. It was installed from July through September of 1982.

The fuel-handling system consisted of four basic components:

1) storage in a highway truck tanker;

2) pumping/straining with a 15-hp centrifugal pump and fuel strainer, with backup for each;

3) fuel transport through a 5-cm galvanized steel pipeline with pipe-threaded fittings; and

4) an injection system having a return loop with flow control valve as well as controlled atomizing air used to inject the fuel nozzle.

Following equipment installation, the local Ministry of Labour inspector was called upon to inspect the facility. A hydrostatic pressure test of the piping system was recommended by the inspector. In addition, before the combustible liquid waste was burned, diesel fuel was substituted to give operational personnel experience with the equipment and its control.

Concurrent with the installation of preliminary burn equipment in the July to September 1982 period, information sessions were held with the majority of plant employees. These sessions gave personnel an understanding of the types of materials to be used as fuel, outlined the three stages of the project, and offered a visual presentation of the General Portland Incorporated facility in Paulding, Ohio. In addition, the employees directly involved with the operation or maintenance of the equipment were trained on system operation and occupational health and safety requirements. Arrangements were then made to transfer combustible liquid waste from the Paulding facility.

A total of 70 000 L were imported subject to Revenue Canada regulations and burned over a 100-hour period between September 28 and October 4, 1982. The materials had been sourced and blended to the fuel specification shown in Table 5 by SYSTECH for use as a fuel in a rotary cement kiln.

5.2 Observations

The following observations were made during the preliminary test burn.

- The Woodstock plant laboratory tests indicated that there were no quality problems with cement made during the preliminary burn.

- The employees were able to handle all aspects of the proposed system safely.

- The strainers installed to remove solid particles greater than 0.32 cm in diameter performed well from the standpoint of removing solids. However, they required excessive maintenance and were not

regarded as being suitable for this operation.

- Although the threaded-pipe transport system worked without leakage, it became evident that it was not suitable for use on an extended burn as originally planned. A welded-steel pipeline would be required.

The following conclusions were drawn at the end of this preliminary test burn.

- The Woodstock plant should proceed with its application for an air permit (*Environmental Protection Act*, Section 8) so that the extended test burn could be undertaken.

- The fuel-handling system used during the preliminary test burn required redesigning for use in the extended test burn. Design of a system for the extended test burn should therefore begin.

5.3 SYSTECH's Role

During the preliminary test burn and the extended test burn, SYSTECH provided the receiving, handling and analysis of all combustible liquid waste entering the Woodstock plant. Under a long-term program, SYSTECH would be able to certify the composition of the combustible liquid waste for Lafarge and the Ministry of the Environment. Long-term supply of combustible liquid waste to the Woodstock plant would be organized and managed by SYSTECH on behalf of Lafarge. This would require the negotiation of contracts, verification of insurance coverage, and the review of permits and licenses. The entire procedure would fall under Regulation 309 of the *Environmental Protection Act* with regard to generator registration and the use of the mandatory manifest system.

Section 6

Extended Test Burn

6.1 Test Burn Objectives

With the completion of the preliminary test burn, a number of objectives were set by Lafarge for the extended test burn which lasted for 90 days. The objectives were established as follows:

(i) to assess the environmental aspects of burning combustible liquid waste as fuel;

(ii) to assess the occupational health and safety aspects of processing combustible liquid waste;

(iii) to assess the quality of cement produced while using combustible liquid waste as fuel;

(iv) to assess the SYSTECH procedure used to source combustible liquid waste;

(v) to provide the public with a direct means of observing the project in action and to assimilate their observations;

(vi) to assess the stability of the kiln operation while using combustible liquid waste as fuel;

(vii) to assess the suitability of the design and equipment installed to process combustible liquid waste;

(viii) to assess the means of transporting combustible liquid waste to the Woodstock plant; and

(ix) to assess the suitability of the emergency response plan in effect during the extended test burn.

In order to achieve these objectives, Lafarge was required to meet four basic requirements:

- design and install **a system** to process combustible liquid waste for use as a fuel;
- apply for and obtain the necessary government **permits** to carry out a 90-day test burn (see Appendix C);
- initiate a **public information plan** (see Appendix B); and
- develop a list of field tests and laboratory analyses, and a **test protocol** which addressed objectives (i), (ii) and (iii).

As of August 29, 1983, all was in order to begin the extended test burn.

6.2 System Design

The equipment for the extended test burn was designed and installed between November 1982, and June 1983. This construction was largely performed by Lafarge personnel. The design of the system was reviewed by the Ontario Ministry of Labour and it was inspected by Lafarge's insurance company. Construction procedures were monitored by the Ministry of Labour, Construction Department, and by the Ministry of Consumer and Commercial Relations, Pipeline Welding. Before construction began, a building permit for the storage facilities was obtained through the Township of Zorra municipal offices.

6.3 Fuel-flow Control Operation

When a fuel tank has been selected for use, the fuel pumping system operates in its "recirculation mode". In this mode, the fuel transport line is pressurized up to the closed

control valve. However, the fuel flow is from the discharge valve of the pump back to the tanks. The fuel flow into the kiln itself was initiated by the "kiln burner" or the plant employee responsible for controlling the kiln process. The desired flow rate in litres per minute is conveyed to the kiln burner by the shift foreman. The flow rate is set by the Lafarge production engineer, process engineer or plant chemist and instructions as to the desired rate for burning are recorded in the shift foreman's instruction book. In setting the flow rate for the fuel, there are two considerations: the maximum allowable flow corresponding to set percentage of kiln heat requirement, and the inventory of combustible liquid waste fuel.

This report and the environmental testing program completed during the 90-day extended test burn were based on a maximum waste fuel addition rate that corresponded to 40% of the kiln's heat requirement. This 40% maximum addition rate per kiln was chosen because of the logistics involved in the fuel procurement sequence. It was also determined by SYSTECH, based on their market survey, that a 20% addition rate per kiln corresponded to a manageable volume of liquid waste that could be procured per week. However, at times when one kiln is down for maintenance procedures, the other kiln would be required to burn the total volume of combustible liquid waste fuel. This means that one kiln would be expected temporarily to incinerate a waste fuel volume equivalent to 40% of the normal fuel volume.

Steady fuel flow is also a requirement for good kiln operation. As a result, the inventory of combustible liquid waste fuel is an important factor in determining the fuel-flow rate. The flow rate would be calculated in the following manner by the production engineer, process engineer or plant chemist.

1) Heat requirement per hour of kiln operation for both kilns:

$$\frac{\text{heat requirement}}{\text{tonne clinker produced}} \times \frac{\text{tonne clinker produced}}{\text{time}} = \frac{\text{heat requirement}}{\text{time}}$$

2) Heat required from liquid waste:

$$\frac{\text{heat requirement}}{\text{time}} \times 0.20 = \frac{\text{heat requirement}}{\text{time}}$$

3) Volumetric flow rate of liquid waste:

$$\frac{\text{heat requirement}}{\text{time}} \div \text{heat content of waste} = \frac{\text{volume}}{\text{time}}$$

Alternatively, if the flow rate is below the 20% addition rate and the inventory of fuel available is limited, the calculation is made in the following manner:

4) $$\frac{\text{volume fuel available}}{\text{time before more available}} = \frac{\text{volume}}{\text{time}}$$

It should be noted in these calculations that the "heat requirement/tonne of clinker" and "tonne clinker produced/hour" are terms that cannot be determined at a specific time in the cement-making process. They can only be based on average figures taken from production records.

Once a tank has been emptied of fuel or surrendered for reuse before being fully depleted, Lafarge stops burning fuel from that particular tank and the next tank discharge is initiated. Lafarge then verifies that the empty tank is ready for refilling by returning the tender document to SYSTECH. The tag indicating that the fuel is acceptable for burning is removed from the tank when it is empty and returned for reuse. This fuel procurement sequence must be repeated before Lafarge can burn fuel from that particular tank again.

6.4 Emergency Response Plan

The design and operation of the waste management facility was developed to eliminate the possibility of an emergency situation threatening the environment or human health. Due to the nature of the operation, however, the risk of spills or fire cannot be completely eliminated. The emergency response plan served to direct SYSTECH and Lafarge employees in the handling of emergency situations that could occur during operations. The implementation

of the response plan, if required, was the responsibility of the plant's Emergency Coordinator. The Emergency Coordinator or an alternate person was available 24 hours per day to respond to emergency situations with the assistance of the resident SYSTECH employees.

During the extended test burn, one incident occurred that involved an emergency response. While a truck was offloading, a cap on the pump manifold dislodged and about 130 to 180 L of fuel spilled onto the offloading slab. The SYSTECH employee and the truck driver who were present, began containing the spill with kiln dust. The Emergency Coordinator was then notified and more absorbent dust was moved to the site and spread over the spill. The recovered fuel-dust mixture was stored in metal drums and later disposed of at a licensed waste disposal site. Some of the waste was contained by the offloading slab drainage system. This drainage system directed the spill to the rainwater-holding tank. The waste fuel collected was then pumped out and disposed of at a licensed waste disposal facility. The outcome was positive in that the fuel spill was entirely contained.

6.5 Closure Plan

Closure refers to the final decommissioning of the waste management facility. The purpose of the closure plan was to ensure that the facility would be decommissioned properly and in a manner that eliminated the need for further maintenance and control. The responsibilities for completion of the closure plan rested primarily with Lafarge, although SYSTECH would be required to share certain operational tasks. The financial requirements of the closure plan were handled by Lafarge. A copy of the closure plan as set out in the operations manual, along with all revisions, was kept at the Woodstock plant until closure was complete.

The system used during the extended test burn was decommissioned after the completion of the burn. The decommissioning involved the removal of residual solids from the tanks and pipeline. This material, along with solid material removed from the fuel-straining operation, was disposed of at a licensed waste disposal site. The decommissioning was not expected to be the final one; therefore, not all of the tasks normally involved in the closure plan were performed. Specifically, the tank steam cleaning was not performed and fuel samples remain in storage for future analysis if required. Further details on the extended burn testing are provided in Lafarge's operations manual, which outlines the plan for operating the Woodstock waste management installation.

Section 7

Results of the Extended Test Burn

The extended test burn began on October 5 and ran until December 28. During this time, a number of environmental consultants and government agencies conducted detailed testing programs to determine the potential environmental effects of liquid waste incineration. The testing programs were designed to assess the trace elements emitted by stack emissions and other wastestreams during the extended test period. Testing programs were also conducted to determine how the burning of liquid waste affected the quality of cement products, kiln efficiency, and the health and safety of employees.

7.1 The Ontario Research Foundation Report

The Ontario Research Foundation (ORF) was retained to undertake and report on all stack sampling. The physical and chemical analysis performed by ORF on cement and concrete products was duplicated by Lafarge. The Ontario Research Foundation also extracted solutions from the dioxin and furan kiln stack sampling train and performed an occupational hygiene survey. Results from the testing and analytical program are shown in Tables 7 and 8. The sampling and analysis program for the wastestreams was very extensive and included state-of-the-art dioxin and furan sampling and analysis methods for kiln stack emissions. Zenon Environmental Inc. performed the analysis for dioxin and furan concentrations on all stack sampling train extracts as provided by ORF (ORF, 1984).

Testing took place at 0%, 20% and 40% replacements of current fuels by combustible liquid waste. Three separate tests were completed for each of the test burn conditions. The schedule for these tests is shown in Table 9. The 0% replacement refers to baseline conditions with no combustible liquid waste usage. Sample times were coordinated to allow computation of a mass balance (input vs. output) for the seven heavy metals tested (see Table 8).

In order to assess the release of fugitive emissions during storage tank filling operations, samples of ambient air were collected in the immediate vicinity of the storage tanks. Additionally, the Ministry of the Environment provided ambient air quality monitoring at the plant boundary. The "worst-case" calculated impingement concentrations* are summarized in Tables 10 and 11, and compared with the MOE regulated impingement concentrations. The worst-case impingement concentrations were calculated using the corresponding worst-case emission rates as determined during the testing. The test numbers corresponding to the test dates and the percentage of fuel replaced by combustible liquid waste are indicated in Table 9.

7.1.1 Kiln Stack and Cooler Stack Emissions

Compared to baseline emission rates for trace metals, the average kiln stack emission rate for cadmium, chromium, copper and zinc decreased or remained about the same with the use of combustible liquid waste as kiln fuel. The calculated point of impingement concentration for these four metals reached a

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* An impingement concentration is an air quality measurement taken at ground level to determine the concentration of specific elements in the air.

Table 7 Testing and Analytical Program for Feed and Product Stream Samples

	Stream Designator	Stream Number	Test/Analyses
Feed Streams	Feed Mix (Slurry)	1	Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn)
	Petroleum Coke	2	Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn)
	Liquid Waste*	3	Trace Metals (Ba,Cd,Cr,Cu,Pb,Zn) Trace Organics (Various) Trace Inorganics (S, N, Halogens) Physical Properties (Heat content Viscosity, Solids, PH, Water, Ash, Density)
Product Streams	Clinker	6	Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn) Oxides (SiO_2, Al_2O_3, Fe_2O_3, CaO, M_2O, SO_3, K_2O) Free Lime, Litre Weight
	Cement	7	Oxides (SiO_2, Al_2O_3, Fe_2O_3, CaO, M_2O, SO_3, K_2O) Free Lime, Insolubles Loss on Ignition Concrete Strength Physical Properties (Consistency, Setting Time, Air Content, Fineness, Early Stiffening, Potential Expansion)

* Analyses completed by SYSTECH Corporation on a routine basis when burning combustible liquid waste.

NOTE: Streams 4 and 5 correspond to natural gas and gypsum in the Ontario Research Foundation report. These streams were not sampled or analyzed.

maximum of 66% of the MOE-regulated impingement concentration with zinc.

The average lead emission rate from the kiln stack increased almost threefold over average baseline conditions with the use of combustible liquid waste as fuel. However, the corresponding impingement concentration for the worst-case emission rate was about 100 times less than the MOE-regulated impingement concentration.

Average emission rates of particulate, sulphur dioxide and nitrogen dioxide from the kiln stack all decreased with increasing usage of combustible liquid waste as fuel. The corresponding calculated impingement concentration was a maximum for nitrogen dioxide at 30.2% of the MOE regulated impingement concentration.

Total hydrocarbon concentration measured in the kiln stack emissions, which is reported as methane, appeared to be influenced by the substitution of combustible liquid waste as

Table 8 Analytical Program for Intermediate and Wastestream Samples

	Stream Designator	Stream Number	Test/Analyses
Intermediate Streams	Kiln Return Dust	8	Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn)
	Clinker Cooler Dust	9	Leachate Toxicity
Wastestreams	Kiln Waste Dust	10	Leachate Toxicity Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn) Oxides (SO_3, K_2O)
	Kiln Stack Emissions	11	Trace Metals (Ba, Cd,Ca,Cr,Cu,Pb,Zn) Trace Organics (Dioxins, Furans)* Particulate Material Chlorine Species (Chlorine, Chlorides, Gases (SO_2, NOx, Total Hydrocarbon, CO_2, O_2)**
	Cooler Stack Emissions	12	Trace Metals (Ba,Cd,Ca,Cr,Cu,Pb,Zn) Particulate Material

* Sampling performed by Ontario Research Foundation. Analyses completed by both Zenon Environmental and the Ministry of the Environment.

** Continuous monitors utilized.

Table 9 Stack Test Schedule and Test Number Reference

Test No.	Test Date	Percentage of Fuel Replaced by Combustible Liquid Waste
1	August 30, 1983	0%
2	September 2, 1983	0%
3	September 3, 1983	0%
4	October 12, 1983	20%
5	October 13, 1983	20%
6	October 18, 1983	20%
7	October 20, 1983	40%
8	October 21, 1983	40%
9	October 22, 1983	40%

Table 10 Stack Emissions (Stream 11) Concentrations

Contaminant	Test No.	Calculated Impingement Concentration ($\mu g/m^3$)	Regulated Impingement Concentration ($\mu g/m^3$)
Particulates	1	22.0	100.0
Hydrogen Chloride	7	10.3	100.0
Chlorine	3	1.6	300.0
Cadmium	1	0.001	5.0
Chromium	7	0.047	30.0
Copper	1	0.15	100.0
Lead	5	0.11	10.0
Zinc	1	0.66	100.0
Sulphur Dioxide	1	186.0	830.0
Nitrogen Oxide	2	151.0	500.0
Dioxins	5	4.7	450*
Furans	6	9.1	22 500*

* Provisional Guideline

fuel. As the addition of liquid waste increased to 40% of the kiln heat requirement, the concentration of total hydrocarbons doubled over baseline conditions. It should be noted, however, that the maximum average concentration reported was less than one half of the MOE-regulated concentration limit.

The average emission rate of chlorides from the kiln stack, which is reported as hydrogen chloride, increased fourfold over baseline conditions at the 40% addition rate of combustible liquid waste as fuel. However, the maximum calculated impingement concentration was only 10.3% of the MOE-regulated impingement concentration for hydrogen chloride.

The average emission rate of dioxins and furans from the kiln stack were measured:

At baseline - 0.26 µg/s dioxins
1.39 µg/s furans

At 20% liquid waste fuel - 0.99 µg/s dioxins
1.81 µg/s furans

At 40% liquid waste fuel - 0.21 µg/s dioxins
0.84 µg/s furans.

The cause of and the differences in these emission rates is not understood. The differences could be a function of the kiln operating conditions, laboratory analysis or other factors. In determining these emission rates, the laboratory analysis requires the determination of minute concentrations in the parts per trillion range (part per trillion corresponds to one second in 33 000 years), which reflects a very difficult proposition, both from the standpoint of field testing and laboratory analysis. It should be noted, however, that the calculated impingement concentrations based on Zenon's analysis for the worst-case emission rates are 77 and 2163 times less than the MOE provisional guidelines for dioxins and furans respectively. These provisional guidelines are set out in detail in the ORF Report (ORF, 1984).

The average emission rates from the clinker-cooler dust collector stack for particulate and heavy metals decreased or remained the same

Table 11 Comparison of Concentrations for Cooler Stack Emissions*

Contaminant	Test No.	Calculated Impingement Concentration (g/m^3)	Regulated Impingement Concentration (g/m^3)
Base		56.75	
Particulate Material	7	4909.00**	100
	3	84.60***	100
Cadmium	8	0.003	5
Chromium	7	0.647	30
Copper	7	0.159	100
Lead	7	0.403	10
Zinc	1	9.59	100

* Cooler stack modelled as a volume source, nearest receptor - west 446 m.

** During Test No. 7, the clinker-cooler baghouse was automatically bypassed due to high gas temperature. If the baghouse is not bypassed, the high temperatures would destroy the filter media. This bypass is the reason that Test No. 7 exceeded the regulated impingement concentration.

*** Maximum emission rate for test without baghouse bypass.

with increasing usage of combustible liquid waste as fuel. Particulate emissions from the clinker-cooler dust collector were about 85% of the maximum allowable impingement concentrations. When the dust collector was bypassed, emission regulations were exceeded. This condition prevailed whether or not supplementary fuels were burned. The cooler recirculation air equipment now installed on both kilns has eliminated these bypass incidents. Because the dust collector handles about 10% of the former air volume, the emission rate during regular operations is also reduced. As a worst-case situation (with the dust collector operating), the maximum emission rate of heavy metals occurred with zinc, but this corresponded with a calculated impingement concentration of only 10% of the MOE-regulated impingement concentration.

As these findings would indicate, all emission levels were below the provincial regulations and/or guidelines, with the exception of the cooler stack when the dust collector was not operational. This condition applied regardless of whether or not supplementary fuel was being used. The cooler recirculation equipment has eliminated bypass incidents. It has, therefore, been concluded that there is no significant difference in emission levels when burning combustible liquid waste. In fact, in the case of particulate matter, the emission rate from the kiln stack dropped when combustible liquid wastes were utilized as fuel.

7.1.2 Kiln Waste Dust

During the three-month test burn, the kiln waste dust generated was deposited in the existing plant landfill site. The waste dust met the MOE leachate test requirements with

the exception of cadmium levels. For two of the nine test results using 40% supplementary fuel (Tests No. 7 and No. 8), the cadmium level was two orders of magnitude higher (see Table 11). The results of the MOE leachate test are summarized in Table 12. The table does not include the organic analysis. Reference should be made to the ORF report for individual results (ORF, May 1984).

The amounts of organics detected were less than 10% of the provisional guidelines. It should be noted that PCBs, reported as Aroclor 1254, were detected in the leachate at levels which were 2% of the provisional guidelines. This laboratory finding has been of concern considering that PCBs are not used in the cement-manufacturing process. It is also puzzling that these organics would be present in the dust leachate even at levels of less than one part per billion considering the high temperature and long residence times associated with the kiln. Given the high affinity of PCBs for solid materials, the presence of PCBs in the leachate would not be expected unless PCBs were present in the solids in high concentrations of 10 ppm. To investigate this, six test pits were excavated in the landfill and a composite representative sample was collected from each pit . Samples were sent to an independent test laboratory for total PCB analysis. In all cases, PCBs were not detected above the detection limit of 1 ppm. This investigation demonstrates that PCBs are not a matter of concern.

Since the time of the extended test burn, changes have been made to the manufacturing process so that the wasting of kiln dust is not required. This situation will prevail as long as fly ash is available from nearby thermal power generating stations. This supply is reasonably assured for the foreseeable future through signed contracts and business licenses. With respect to the landfill area, Lafarge conducted a hydrogeological study of the site and is monitoring groundwater and surface water to ensure that contaminants are not released to the environment. The landfill pile has been capped with an impervious clay layer and a formal submission for a Certificate of Approval under Part V of the *Environmental Protection Act* is currently being made to the Ministry of the Environment.

7.1.3 Additional Test Results

Total hydrocarbon concentration, which is reported as methane, in the tank farm area while using and transferring the combustible liquid waste, was in the range of 0 to 4 ppm. Similar values were measured in this area before any combustible liquid waste was brought on site.

The quality of the cement produced while using combustible liquid waste as a fuel was found by ORF to meet the requirements of the Canadian Standards Association (CSA) and the American Society for Testing and Materials (ASTM), where applicable. In addition, Lafarge performed testing at the Woodstock plant laboratory and the Lafarge Research Laboratory in Belleville, Ontario. These results are addressed in a separate report, which is summarized in Subsection 7.1.5 of this report. Lafarge's work corresponds to the ORF findings.

7.1.4 Occupational Hygiene Report

The Ontario Research Foundation performed an occupational hygiene survey to determine concentrations of toluene and xylene that Lafarge employees may be exposed to during their normal duties in the waste fuel storage and pumping area. It was intended that this testing would assess the need for Lafarge employees to wear organic vapour respirators. The ORF report should be referred to for details (ORF, 1984).

The testing program, as shown in Table 13, was developed to assess both normal and worst-case exposures to the organic vapours.

The testing consisted of the following.

- A sampling device was attached to the Lafarge employee who was carrying out

Table 12 Leachate Extraction from Kiln Waste Dust (Ontario Ministry of the Environment)

	Test No. 1 mg/L	Test No. 2 mg/L	Test No. 3 mg/L	Test No. 4 mg/L	Test No. 5 mg/L	Test No. 6 mg/L	Test No. 7 mg/L	Test No. 8 mg/L	Test No. 9 mg/L	Maximum Allowable Concentration* mg/L
Inorganics										
Free Cyanide	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	20
Fluoride	6.7	5.3	4.8	11.4	14.6	12.8	15.5	15.5	15.0	240
Nitrate	nd	nd	nd	nd	nd	nd	nd	nd	nd	1000
Nitrite	nd	nd	nd	nd	nd	nd	nd	nd	nd	
Metals										
Arsenic	0.001	0.001	nd	nd	0.002	0.004	0.001	nd	0.005	5
Barium	0.55	0.63	0.67	0.38	0.18	0.18	0.16	0.22	0.23	100
Boron	0.06	0.02	0.03	0.11	0.19	0.23	0.23	0.15	0.21	500
Cadmium	0.005	0.005	0.005	0.005	0.005	0.005	0.84	0.97	nd	0.5
Chromium	0.03	0.03	0.04	0.22	0.07	0.07	0.05	0.04	0.05	5
Lead	0.4	0.4	0.42	0.13	0.35	0.09	1.8	1.6	0.1	5
Mercury	nd	0.0001	nd	0.0002	0.0001	0.0002	0.0002	0.0003	0.0001	0.1
Silenium	0.025	0.055	0.042	0.04	0.11	0.43	0.01	0.09	0.07	1
Silver	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	5
Uranium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	2

* Maximum allowable concentration is 100 times the drinking water standard

nd = not detected

Table 13 Sampling Data for Toluene and Xylene Monitoring (Canada Cement Lafarge Ltd.)

Sample Number	Location/ Operator	Sampling Notes	Period of Sampling Time On	Time Off	Volume of Air Sampled (m^3)*
December 15					
1	Kiln Oiler	General Duties	10:23	3:27	0.016
2	Pump House	Over storage tank by pump hook-up	10:10	3:24	0.017
3	Kiln Oiler	Cleaning the strainer	1:22	2:14	0.009
December 20					
1B	Pump House	Pumping station	10:20	3:22	0.016
2B	Kiln Oiler	General duties	10:17	3:24	0.016
3B	Kiln Oiler	Cleaning the strainer	1:22	2:26	0.011

* Corrected for temperatures of 0 °C on December 15, 1983, and -10 °C on December 20, 1983.

normal operating procedures within the waste storage and pumping area.

- A sampling device was attached within the pump house area to simulate the worst-case situation of an employee remaining directly exposed to the vapours within the pump house for a complete shift.

- A sampling device was attached to the Lafarge employee who was responsible for dismantling and cleaning the fuel strainers. This job is of short duration compared to general duties, but was expected to expose the employee to higher vapour concentrations.

The testing results are shown in Table 14. They were compared to the Ontario Ministry of Labour guidelines for the maximum time weighted average exposure criteria of 100 ppm for both xylene and toluene. Toluene and xylene were chosen as the organics to test because they are present in highest concentrations within the fuel. The results met the guidelines, indicating that there would be no exposure problem for the employees. However, the suggestion made by ORF to wear the respirators while cleaning the strainers would be followed as a minimum requirement and as an additional safety precaution.

7.1.5 Supplementary Study by Lafarge

Lafarge duplicated and extended the testing performed by ORF on the plant's products. The purpose of the testing was to compare the quality of cement before and after using combustible liquid waste as fuel in the rotary cement kilns.

Table 14 Toluene and Xylene Concentrations (Canada Cement Lafarge Ltd.)

Sample Number	Location/Operator	Toluene (µg) (Corrected for Blanks)	Xylene (µg) (Corrected for Blanks)	Average Airborne Concentrations Toluene (mg/m^3)	Toluene (ppm)	Xylene (mg/m^3)	Xylene (ppm)
December 15, 1983							
1	Kiln Oiler	0.42	1.06	0.028	0.007	0.071	0.016
2	Pump House by Hook-Up	13.92	11.06	0.819	0.218	0.651	0.15
3	Kiln Oiler	33.62	31.96	4.2	1.12	4.0	0.92
December 20, 1983							
1B	Pump House Pumping Station	16.2	6.3	1.16	0.31	0.45	0.103
2B	Kiln Oiler	12	5.6	0.75	0.2	0.35	0.08
3B	Kiln Oiler	121.3	47.8	11.02	2.9	4.35	1

Note: Ontario Ministry of Labour guideline for xylene and toluene vapour concentration is 100 ppm.

The Lafarge analytical work was performed at the Woodstock plant laboratory or the Belleville, Ontario research facility. The test methods used were standard ones normally used in testing to CSA or ASTM standards. The tests performed were those normally performed to assess the quality of raw materials, clinker, cement and the resulting concrete. In addition, metals analysis was performed on the cement. The results of the testing performed by Lafarge indicate that, while there was some fluctuation in the parameters tested, cement did not differ significantly in quality after combustible liquid waste was used as fuel.

The analysis of cement for heavy metals indicates generally a small increase in heavy metal concentrations with increasing combustible liquid waste fuel usage. The heavy metal levels were below the levels considered to have an effect on the finished cement product. There was no observed detrimental effect on the cement as a result of the increase in heavy metal concentration.

7.2 Ministry of the Environment Test Results

The Ministry of the Environment performed a number of monitoring and testing functions during the extended test burn. Many of the tests dealt with various samples of dust from the kiln which were analyzed for concentrations of dioxins and furans. The analysis for dioxin and furan concentrations in the process solids was completed at the MOE dioxin laboratory in Toronto. The samples analyzed were derived from composites of three tests that were designed to assess emissions resulting from the addition of liquid waste. Two of the tests measured emissions that resulted from the addition of liquid waste at 40% and 20%, while the third test measured emission levels taken without the addition of liquid waste to the kiln fuel mix (the baseline category).

In addition to these functions, the Ministry of the Environment performed the following:

- an ambient air quality survey in the vicinity of the Woodstock plant during the extended test burn;
- analysis of random samples of waste fuel for the same parameters as SYSTECH adopted in the fuel specification;
- duplication of a portion of the dioxin and furan analysis (the impinger extract) as a quality assurance check with respect to the work of Zenon Environmental Inc.; and
- monitoring of the stack sampling techniques used by ORF.

The results of the analysis for polychlorinated dibenzo-*para*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in the dust samples from the Woodstock kiln are presented in Table 15. These results have been assessed as to their effect on the environment and occupational health and safety.

The clinker dust is the small particulate fraction of the kiln product and is normally recombined with the finished product clinker. Periodically, as maintenance is required on the dust collector, the clinker dust may be discharged on the ground and transferred to the landfill site. Since the results of the MOE leachate toxicity test (ORF, 1984) for the clinker dust indicate that concentrations of dioxins and furans were all below the detection limits of the analysis method, the clinker dust is not an environmental concern.

The kiln return dust can be collected by the electrostatic precipitator and returned to the kiln process. The return dust eventually becomes part of the finished product (clinker). There is a possibility that some of this return dust could be re-entrained in the air stream as it is introduced to the kiln and

Table 15 **Polychlorinated Dibenzo-*para*-dioxin/Polychlorinated Dibenzofuran (PCDD/PCDF) Concentrations Present in Lafarge Dust Samples**

	Cooler Waste			Kiln Return			Kiln Waste		
	Baseline	20%	40%	Baseline	20%	40%	Baseline	20%	40%
T_4CDD	nd	nd	nd	nd	nd	0.01 (1)**	0.01 (1)	0.03 (2)	0.10 (4)
P_5CDD	nd	nd	nd	nd	nd	nd	nd	0.07 (2)	0.40 (3)
H_6CDD	nd	nd	nd	nd	nd	1.2 (5)	nd	0.50 (2)	7.8 (5)
H_7CDD	nd	nd	nd	nd	0.02 (1)	0.2 (2)	nd	0.20 (2)	2.5 (2)
OCDD	nd			nd	0.2	0.4	nd	0.1	2.9
Total	nd	nd	nd	nd	0.22	1.8	0.01	0.9	14
T_4CDF	nd	nd	nd	nd	nd	0.02 (4)	nd	0.06 (3)	0.40 (11)
P_5CDF	nd	nd	nd	nd	nd	0.04 (1)	nd	nd	0.90 (10)
H_6CDF	nd	nd	nd	nd	nd	0.30 (4)	nd	nd	3.0 (6)
CDF	nd	nd	nd	nd	nd	0.10 (1)	nd	nd	0.80 (1)
OCDF	nd	nd	nd	nd	nd		nd	nd	0.04
Total	nd	nd	nd	nd	nd	0.46	nd	0.06	5.1
Percent Recoveries									
13C-TCDD	100	83	nd	53	61	110	41	89	100
13C-OCDD	72	23	nd	20	28	140	18	50	100

nd = not detected
* All data are in ng/g and corrected for recoveries.
** Numbers in brackets are number of isomers detected

T_4CDD	tetrachlorodibenzo-*para*-dioxin
P_5CDD	pentachlorodibenzo-*para*-dioxin
H_6CDD	hexachlorodibenzo-*para*-dioxin
H_7CDD	heptachlorodibenzo-*para*-dioxin
OCDD	octachlorodibenzo-*para*-dioxin
T_4CDF	tetrachlorodibenzofuran
P_5CDF	pentachlorodibenzofuran
H_6CDF	hexachlorodibenzofuran
CDF	chlorinated dibenzofuran
OCDF	octachlorodibenzofuran

becomes kiln waste dust. Although dioxins and furans were detected in the return dust, the return dust is not landfilled and is therefore not a concern from the standpoint of the environment related to the on-site landfill.

7.2.1 Occupational Health and Safety Standards

Although there are no occupational health and safety exposure standards related to dioxins and furans, the potential levels an employee may be exposed to must still be addressed. Employees within the plant may at times work in areas where the return dust or the waste dust is entrained in the air they breathe.

Two different conditions of dust exposure and the resulting dioxin and furan concentrations have been addressed in Table 16. The first condition, referred to as A in Table 16, is the dioxin and furan concentrations experienced by an employee continually exposed to the maximum dust concentration without protection as regulated by the Ontario Ministry of Labour; its standard is 10 mg/m^3.

The second condition, referred to as B in Table 16, is the dioxin and furan concentration experienced by an employee continually exposed to dust concentrations with the protection of a dust mask capable of limiting the dust concentration to 0.05 mg/m^3. By using the MOE Provisional Guideline of 30 pg/m^3 for maximum annual average concentration of dioxins and furans in the environment, and comparing those guidelines with the concentrations in Table 16, there is only one situation where the provisional environmental guideline was exceeded.

At the 40% addition rate of combustible liquid waste as fuel, an employee would be exposed continually to 10 mg/m^3 waste dust in the air. This level of waste dust would exceed the provisional environmental guideline by 4.7 times. This situation indicates that a dust mask would be required by an employee exposed to such abnormal conditions. It should be noted, however, that within the routine of jobs in the plant, continuous exposure to dust concentrations near the 10 mg/m^3 limit is highly unlikely.

7.2.2 Ambient Air Quality Survey

During the month of November 1983, the Ministry of the Environment performed ambient air quality monitoring during five different operating days. The work was performed by the Monitoring and Instrumentation Development Unit, Atmospheric Research and Special Programs Section of the Ministry's Air Resources Branch. The group used its Mobile Air Monitoring Unit No. 1 (Mamu No. 1) to carry out this work. The goal was to assess the ambient air quality in the vicinity of the plant during various operating conditions and to compare the air quality with standards,

Table 16 Concentrations of Dioxin and Furan in Air (pg/m^3)

Condition	0% Waste Fuel	20% Waste Fuel	40% Waste Fuel
Kiln Return Dust			
A	0	2.2	18.1
B	0	0.01	0.09
Kiln Waste Dust			
A	0.10	9.0	141
B	0.005	0.045	0.71

Provisional Guideline = 30 pg/m^3

guidelines or provisional guidelines where available. Table 17 shows the date of the tests, as well as the fuel type used within the kiln. The parameters tested were common regulated gaseous contaminants, such as carbon monoxide, ozone and oxides of nitrogen.

In addition, a total of 26 selected hydrocarbons were tested for in the ambient air. The hydrocarbons, which were generally present in the combustible liquid waste fuel, are listed in the ORF report (ORF, 1984). The measured concentrations were to be compared with Ministry of the Environment standards, guidelines and provisional guidelines where available, for all parameters tested.

As indicated in the MOE report (1984), the environment downwind of the plant was tested during operating conditions with and without combustible liquid waste fuels. The common regulated gaseous contaminants were found to be within air quality criteria, except on November 10, 1983. On this day, both concentrations of carbon monoxide (CO) and oxides of nitrogen (NO_x) showed elevated values when Mamu No. 1 was not in a position to monitor emissions from the Lafarge plant stack.

Of the 26 selected hydrocarbons tested, none of the concentrations measured by the Ministry of the Environment exceeded available standards and guidelines.

On November 23, 1983, the plant was operating under the full array of conditions (with and without combustible liquid waste fuel and during offloading procedures of fuel trucks). There were no enhancements or distinguishing irregularities seen in the concentrations of the 26 selected hydrocarbons monitored as stated in the MOE report (1984).

7.3 Transportation Issues

A number of different trucking companies carried the material to the Woodstock plant. SYSTECH and Woodstock personnel evaluated which companies would be suitable for future material hauling, based on their reliability, environmental awareness and handling procedures. Transportation would be designed to comply fully with Regulation 309 of the *Environmental Protection Act.*

The impact of the waste delivery program was assessed with respect to the traffic volume on the routes to be used. During the test burn, the maximum number of trucks received per day was three. In connection with the proposed permanent facility, it is projected that a maximum of eight trucks per 16-hour operating day would be expected.

Two of the routes involved in the waste delivery program, the 401 and Highway 2 (Governor's Road), had traffic volumes of 19 500 and 4 500 vehicles respectively (annual daily average, Ministry of Transportation). Therefore, the addition of eight more vehicles to the existing traffic volume would have no significant environmental impact.

Of particular importance is the fact that the highway in front of the plant has been designed to permit the safe entrance and exit of large, often slow-moving, transport trucks.

Table 17 Fuel Mixtures Used during Various Ambient Air Quality Tests

Test No.	Date	Plant Operating Condition
1	Nov. 10, 1983	- regular fuels used
2	Nov. 10, 1983	- regular fuels used
3	Nov. 11, 1983	- regular fuels used
4	Nov. 22, 1983	- regular fuels used
5	Nov. 22, 1983	- regular fuels used, unloading tanker
6	Nov. 22, 1983	- regular fuels used, unloading tanker
7	Nov. 23, 1983	- 20% liquid waste fuel, unloading tanker, regular fuels
8	Nov. 24, 1983	- liquid waste fuel at 20%
9	Nov. 24, 1983	- liquid waste fuel at 40%

Section 8

Emission Control Upgrading at the Woodstock Plant

8.1 Control Order Requirements

The supplementary fuel-burning trials conducted in October 1983, indicated that some areas of the plant required emission control improvements. Subsequent to this, a study of all plant operations was conducted by provincial abatement officers of the Ontario Ministry of the Environment. This study was done with the full cooperation of plant operations personnel. The study identified those points of emission that needed improvements for supplementary fuel burning, such as the kiln stacks and the landfill site. The study also reviewed areas of concern to local residents, such as clinker dust emissions and storage silo emissions.

On the basis of this study, the plant was served with a control order in April, 1986. The control order specified that Lafarge had to make improvement proposals to the Ministry and, upon MOE approval, the company would have to implement such measures according to a negotiated schedule. The study identified 12 areas of improvement and since that time two additional concerns have been recognized.

Lafarge has made a commitment not only to meet all requirements of the control order but to improve its emission standards in all areas of plant operations. This commitment goes beyond improving pollution control equipment; it involves economical and practical improvements designed and engineered at the Woodstock plant itself to become a permanent part of the plant's operation. It has also involved changing the attitude of all Lafarge employees so that dusty conditions are no longer considered an unavoidable part of cement manufacture. The idea that pollution control is everybody's business will be part of this changing attitude.

8.2 Emission Reduction Measures

A summary of the progress made by Lafarge in upgrading the identified areas of concern follows.

1) Kiln ESP Outages - Kiln stack particulate emissions are the primary source of dust release to the environment from the plant. Most of the dust is emitted when the electrostatic precipitators (ESPs) are de-energized. The following measures have been implemented to reduce these outages:

- a training program to eliminate outages caused by operator error with a follow-up policy for all incidents;
- a revised start-up procedure to reduce outages during the most susceptible period;
- an improved solid-fuel firing system that provides the kiln operators with better control of the burning process; and
- more sensitive exit gas analyzers to accurately indicate the firing conditions.

With these improvements, ESP outages have been markedly reduced. In 1986, the outages averaged 87 minutes per month. In 1987, this average was reduced dramatically to 29 minutes and, in 1988, Woodstock achieved a further decrease to 17 minutes per month.

In addition to efforts to eliminate outages, a program was undertaken to upgrade the collection efficiency of the precipitators. Cold air in-leakages have been reduced through more effective sealing of hoppers and

return dust conveyors. This has stabilized and reduced the volume of gases being processed by the ESPs. Microprocessors have been installed to optimize the voltage in the dust-collecting fields of the precipitators. Also, extensive changes have been completed to the chain heat exchangers in both kilns that reduce the dust loading into the precipitators. Further steps have been implemented with regard to raw mix uniformity and centralized control that have produced significant improvements.

2) Clinker Cooler Emissions - Air is normally vented from the clinker coolers to the atmosphere through a bag-dust collector. As the vented air is hot, a special glass fabric is used as bag material. Sometimes the cooling air temperature is too high and the dust collector is bypassed to prevent damage to the bags. During these high temperature periods, the air is vented directly to the environment with no dust collection. To prevent this occurrence, an air circulation system has been installed on both kiln processes. Most of the vent air is now recirculated as process air so that the dust collector handles only 10% of its former volume. The hot gas that is handled by the dust collector can be diluted with relatively cold ambient air. As a result of these changes, bypass incidents rarely occur on these kiln systems.

3) Mill Number 4 ESP - The largest of the four cement-grinding mills is equipped with an electrostatic precipitator instead of a bag collector. During system start-up when the mill water spray is off, the ESP can shut down due to electrical overload. Cement dust is vented to the atmosphere during these periods. Equipment to overcome these two conditions has been installed but is not yet completely effective and is still undergoing tests. Automatic voltage controllers are being installed to eliminate the problem.

4) Coal and Petroleum Coke Handling and Storage - The problem is created by fugitive dust emissions from the receiving and unloading of trucks, the front end loader-blending procedures, and wind erosion from the stockpiles. Petroleum coke is finer than coal and causes essentially all of the dust emission. The following abatement measures have been implemented:

- controlled dumping of incoming trucks;
- spraying of stockpiles with a crusting agent; and
- using irrigation spray equipment to soak all petroleum coke inventories.

These measures have significantly improved the fugitive dusting conditions in this area. In addition, a solid fuel blending station has been installed, which reduces the handling operations and the potential for dusting conditions even further. Also, the coke storage area has been divided into three cells; the fuel is dumped into one cell and is allowed to capture moisture in the second cell. It is then taken for use from the third cell. The objective of this system is to reduce fugitive dust by ensuring that only moisturized coke is handled.

Soaking the petroleum coke with water may be effective in reducing dust but an economic penalty is incurred because this water must be evaporated in the burning process. To resolve this question, Lafarge is investigating agglomeration and pelletizing processes for fluid petroleum coke.

5) Storage Silo Dust Collection - The 13 cement storage silos constructed with the original plant were never equipped with dust collectors. During filling and unloading operations, dust emissions were evident in the silo roof vents. Eight new bag collectors have been installed and dusting conditions have been eliminated.

6) Limestone Discharge into Storage - After crushing, the limestone is dropped from a conveyor to a stockpile. This operation created significant quantities of fugitive dust. Water spraying is effective in reducing the

dusting condition to minimal levels. During winter operations, water sprays cannot be used because frozen lumps form which cause handling and process problems. Experiments have been conducted using different types of chemical sprays, applied in different locations. It was determined that the amount of chemical sprayed on the stone could be varied with the prevailing weather. For example, freeze-dry winter conditions required more chemical spray to eliminate fugitive dust. From this research, an optimum material and position were determined for the application point which was installed, winterized and used throughout the winter of 1986 to 1987 with good results.

7) Dust Collector Maintenance and Operations - From a review of plant operations, it was observed that dust collector maintenance had assumed a lower priority than equipment operation. The result was that abatement equipment could run unattended - for example, with broken bags. A formal preventive maintenance program has subsequently been designed and implemented. With this system, a maintenance inspector observes the operation and general condition of all plant dust collectors. The inspection follows a predetermined checklist at weekly, monthly and semi-annual intervals. The system has been in operation for more than a year and has produced a marked improvement in general dust abatement. This is reflected in employee attitudes; excessive emissions are promptly reported and equipment is not considered to be available for operation unless the dust collectors are working satisfactorily. The inspection part of the program has worked well but on occasion the completion of the repairs has a lower priority. To counteract this problem, it is planned to form a dust collector crew to repair and maintain these units. Specialized training will be provided.

8) Clinker Dust at Discharge into Storage - Dust is created when the clinker discharges from the conveyor system into the storage area. This has been a difficult problem to solve since water and chemical sprays react with the clinker and negatively influence its performance when ground into cement. Initially, a vertical chute with several flap openings was constructed to contain the fugitive dust and reduce the free-fall height. It was not successful. In fact, the chute created a chimney effect that tended to worsen the dust conditions. Two chemicals have since been found that have a minimal influence on cement performance. Spray trials have indicated that one of these chemicals is quite effective in suppressing clinker dust, although it is prohibitively expensive. Negotiations are currently underway to formulate an equally inert and effective chemical at a lower cost as well as experimenting with other manufacturers' products.

9) Monthly Reporting - The Woodstock plant has installed capacity meters on the kiln stacks and other sensors to monitor emission conditions on the clinker coolers and large grinding mill. Lafarge has developed a computer surveillance program, called "Datalogger", that monitors all these emission points at six-second intervals and summarizes the information in daily, weekly and monthly reports. This data is reported to the Regional Office of the Ministry of the Environment on a monthly basis.

10) Fugitive Dust - Considerable truck traffic on the in-plant roads can create significant fugitive dust emissions during dry weather conditions. To improve this situation, the paved roads are cleaned with a vacuum sweeper on approximately a monthly basis. The unpaved roads and general yard areas are sprayed three to four times a year with a chemical dust-suppressant. Recently, a water truck has been obtained and the traffic areas are watered when conditions warrant. A five-year program for paving and grassing the uncovered areas is also underway. Trees have also been transplanted in the general plant area and additional work is planned. These projects have significantly improved fugitive dust conditions around the plant.

11) NOx Emissions - Stack testing was undertaken in June 1987 to determine NO_x emission levels from the kilns. The results confirm the 1983 tests which indicate that on average the NO_x levels are less than half of the maximum allowable limits stipulated in Regulation 308. In addition, the sum of the highest individual measurements of NO_x from each kiln is also below the stipulated limit.

12) Landfill Site - Since the beginning of plant operations in 1956, kiln dust has been removed from the burning process to produce a special type of cement with a low alkali content. This dust has been dumped in one location on plant property. The leachate or run-off water from this landfill site exceeds drinking water objectives for potassium, sodium, chloride and sulphates. As a remedial measure, Lafarge has capped the landfill site with an impervious clay layer. A monitoring program of the surface water and groundwater is underway to ensure that contaminants are not released to the environment. A formal submission for a Certificate of Approval under Part V of the *Environmental Protection Act* is currently being made to the Ontario Ministry of the Environment.

In addition to the 12 items designated in the control order, Lafarge is also participating in noise and odour testing in response to the concerns of local residents. In general, Lafarge has responded to the reasonable requests of its neighbours and to Ministry officials acting on behalf of the local residents. Practical engineering solutions have been sought out and employed so that improvements can become a permanent part of the Woodstock plant's new operational standards.

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Appendix A

Background Information on Lafarge Canada Incorporated, the Woodstock Cement Plant and SYSTECH Corporation

Lafarge Canada Incorporated developed its current status in the cement manufacturing industry through a number of key mergers and investments in modern equipment. The company is actually a Canadian subsidiary of the French cement company, Lafarge S.A. Lafarge Canada's majority shareholder is Lafarge Coppée of Paris, France.

In 1970, Lafarge Canada merged with the Canada Cement Company which resulted in the formation of Canada Cement Lafarge Limited, a name that remained in use until 1987. Its combined resources provided the new company with a stronger financial base, improved marketing opportunities and greater technical depth.

Expansion into the United States began in 1973 with the establishment of a company in the southeast. The Citadel Cement Corporation was started as a joint venture. This joint venture was ended a few years later and Lafarge acquired cement plants in Demopolis and Birmingham, Alabama. In 1981, with the acquisition of General Portland Inc., a major American cement manufacturing company, Canada Cement Lafarge became the largest cement manufacturer in North America with an annual production capacity of 1.24×10^7 t.

Lafarge Corporation, a U.S. parent holding company, was formed in 1983, with Canada Cement Lafarge and General Portland as its two operating subsidiaries.

In 1987, in recognition of the increasingly cross-border nature of its business, the company reorganized its management and operations throughout North America. It established new corporate headquarters in Reston, Virginia, merged the assets of General Portland with those of Lafarge Corporation and changed the Canadian company's name to Lafarge Canada Incorporated. All operations in Canada are now carried out by Lafarge Canada Inc. and its subsidiaries while all operations in the U.S. are conducted by Lafarge Corporation.

Lafarge Canada Inc. continues to maintain a corporate office in Montreal, Quebec, where it has been since 1909. There are three regions across the country to service major market areas. The Woodstock plant is part of the Great Lakes Region, which has its principal Canadian office in Toronto. Lafarge Canada Inc. employs 4 200 people in its cement and construction materials division in Canada.

The Woodstock Cement Plant

The Woodstock plant began producing cement in October, 1956. During 1957, an addition to the plant doubled its productive capacity and in 1967, an additional cement-grinding mill and facilities for increased cement storage capacity were installed. Through these modifications to existing equipment and the manufacturing process, the annual cement production capacity at the Woodstock plant is up to 540 000 t. The combined efforts of 128 employees are required to achieve this production rate.

Since the Woodstock plant is an older facility and its technology is based on the wet process, it is at a competitive disadvantage with other plants. Most plants today employ the dry process which requires considerably less energy. In spite of this, the Woodstock plant has implemented several innovations to help overcome its disadvantages. Many of these innovations have been achieved through

reduced energy consumption and the use of industrial by-products as a source of fuel. The plant also places considerable emphasis on a preventative maintenance program for its equipment, which is now over 36 years old. In spite of its age, the plant's equipment is considered to be in above-average condition. Other aspects of cement plant operation are also being addressed in order to ensure the continued operation of the Woodstock plant. These include environmental controls and effective occupational health and safety programs.

In terms of adapting to meet the needs of the market, the Woodstock plant has done well in expanding its product line over the last 10 to 15 years. The Woodstock plant now produces eight special cements which were developed to meet specific construction requirements. These and other cement products are also easier to obtain due to the development of an efficient truck-loading system in 1967.

By 1979, the plant was employing Great Lakes vessels leaving from Port Stanley, Ontario to expand its market interests even further. Other improvements, such as the recent installation of an automatic rotary bagger and palletizer in 1987, have also helped the plant to meet the increased demand for masonry and other bagged cements. Together, these improvements and innovations have enabled Woodstock to meet the demand for its products and reduce manufacturing costs.

Current Status of Project

Since the decision was made to postpone application for an environmental hearing on Woodstock's resource recovery project, major emphasis has been placed on upgrading the plant's emission control standards and its on-site landfill area. Considerable success has been achieved in both endeavors.

The control order, served in April 1986, identified 12 areas in which emission standards required improvement. These improvements were to be made according to a negotiated schedule. To date, the company has met all deadlines in this respect, and has succeeded in significantly reducing the amount of dust emitted from various areas of the plant operation, in particular in reducing the number of kiln electrostatic precipitation outages. New emphasis is being placed on emission reduction performance and plant enhancement measures.

Work has been carried out to improve the security of the plant's landfill site. Work has been completed on capping the site with an impervious clay layer, and surface and groundwater are being monitored on an ongoing and permanent basis. A Certificate of Approval under Part V of the *Environmental Protection Act* is being sought from the Ontario Ministry of the Environment.

During the process of applying for the latter permit, Woodstock participated in two meetings, held on May 7, 1987 and February 22, 1988. These meetings were attended by representatives of the MOE, Lafarge officials, consultants, members of the opposing Embro Concerned Citizens Committee, environmentalists and interested local citizens. In each case, about 25 people attended. The meetings were held to review the progress being made by Lafarge in its emission abatement program and landfill site. Due to the favorable reception of progress reports resulting from these events, it appears that the company will be able to obtain the landfill permit without resorting to a formal Environmental Hearing. When the MOE expressed this opinion at the second public meeting, there were no objections raised by those present.

Plant employees are being kept informed on an ongoing basis by means of departmental health and safety meetings about progress achieved on the control order, landfill site and the waste-derived fuels project. There is a heightened awareness among those operating the plant of the necessity to operate it as cleanly as possible.

In order to ascertain the amount of suitable wastes available for burning at Woodstock, Lafarge has obtained data on wastes supplied by the Ministry of the Environment. This data, based on the MOE's Waste Manifest System, confirm that an adequate supply of suitable wastes is available.

A recent change in Ontario's environmental legislation is likely to increase the difficulties associated with obtaining a permit to burn liquid wastes as supplementary fuels for cement kilns. Previously, the onus was on the proponent to demonstrate that their proposed operation was a safe and viable one. Under the new ruling, the proponent must go to a full Environmental Assessment Hearing and prove that the facility in question is not only environmentally safe but also better than any other available alternative. To do this, the proponent must include the following four elements in their proposal:

- a rationale of the project;
- consideration of alternatives to the undertaking;
- consideration of alternative sites; and
- consideration of alternative technologies.

While work is being carried out on the emission control order requirements and the landfill site, Woodstock is looking to the future. Once these requirements have been satisfied, there are five possible approaches or options being studied:

- apply for a full permit to burn liquid industrial wastes;
- conduct a longer-term trial (one to two years) to gather additional data while burning supplementary fuels under a temporary test permit;
- select and begin burning a single waste stream, a solvent for example, which is available in large quantities in Ontario. Once this has been successfully and safely burned for a period of time, the plant would look to expanding the types of wastes used;
- study the possibility of burning some alternative type of waste, such as rubber tires; and
- discontinue the project entirely if the regulatory, political and social ambiance is such that permits for these environmentally sound installations appear too costly and time-consuming to obtain.

SYSTECH Corporation

SYSTECH Corporation began operation in 1969 as Systems Technology Corporation, a privately owned U.S. company. Their early experience was in environmental consulting, as well as research and development for industry and government. Operational activities began with aqueous wastewater treatment plants in Ohio. They then branched out into solvent recovery. SYSTECH signed their first contract with General Portland Inc. in 1979 to procure supplementary fuel for the Paulding, Ohio cement plant. The Paulding project has since been hailed as a "model facility" by state regulators. A wholly-owned subsidiary, SYSTECH Environmental Incorporated, was established with the approval of the Federal Investment Review Agency (FIRA) to provide similar services in Canada.

With the acquisition of SYSTECH by Lafarge Corporation in 1986, the operational arrangements of a long-term supplementary fuel program at Woodstock would be the responsibility of Lafarge, using the SYSTECH Division as the management arm. SYSTECH currently manages six facilities in the United States that use combustible liquid waste as fuel in cement kilns. They also manage engineering and consulting groups that provide comprehensive advice on waste fuel recovery programs to suit industrial and government needs.

Appendix B

Public Involvement in the Woodstock Resource Recovery Project

The most pervasive cause of delay or defeat of proposed resource recovery installations is public opposition. Although the public health and environmental risks associated with burning liquid industrial wastes are extremely small, the perception of these risks often shapes public attitudes regardless of the technical facts. Misconceptions, fueled by special interest groups or the media, occur most where lack of knowledge is greatest. In addition, many citizens fear that the proximity of a waste management installation may result in a decrease in local property values.

Once Lafarge Canada had established the feasibility of burning wastes at Woodstock, based on analysis of the technical literature, experience at other plants and completion of the 100-hour preliminary test burn, (September 28 to October 5, 1982), the plant developed a public information program designed to explain the proposed facility to the public, and keep them informed of its progress. The basic strategy of the program was to communicate first with the employees of the Woodstock plant, then to meet with local officials, community leaders and government representatives, followed by the public at large.

The public information program was designed to communicate with and inform all the public interest groups involved (internal and external), the media and interested agencies as openly and effectively as possible about the proposed waste management project. It consisted of six basic elements:

- informing Lafarge employees through the plant's Health and Safety Committee, the Union/Management Committee and individual departmental meetings;
- meetings with government representatives, local officials, and environmental groups;
- public information meeting;
- "open house" at the Woodstock plant;
- presentations to interested groups; and
- public release of test results.

B.1 Chronology of Events

June 1982	Initial contact made with senior officials of the Ontario Ministries of the Environment, Energy and Industry.
June to July 1982	Plant personnel kept fully informed and representatives visited Paulding, Ohio facility.
September 1982	Four-day preliminary test burn successfully conducted.
January to February 1983	Local municipal politicians and community leaders, as well as an Ontario MLA and Federal MP, were informed about the project in a series of meetings.
February 1983	Meeting held with three environmental groups.
January to July 1983	Construction of facilities to store and handle fuel for extended test burn.

March 1983	Public meeting held in local hall. Negative comment in the press followed the public meeting.
April to May 1983	Group of local citizens criticize project. Urge holding of Environmental Hearing. Plant representatives speak to local groups and associations.
May 1983	Ministry of the Environment and Environment Canada representatives meet with local citizens' group opposed to project. MOE decides that a Hearing will be held under the *Environmental Protection Act*.
June 1983	Lafarge offers opposition group the opportunity to establish liaison committee. Group declined at this time.
October to December 1983	Extended test burn conducted with MOE approval. Local people invited to attend "open house" to observe the facility in operation. Test received thorough and positive press coverage.
November 1983	Public meeting held by opposition group to garner support. Fifty people attended, of whom 30 to 35 were considered to be concerned about the project.
May 1984	Data from the Ontario Research Foundation's environmental report were made public. Some negative media comment ensued. Ministry of the Environment officials advised that they would not support Lafarge at a hearing until other environmental matters at Woodstock had been resolved. Lafarge decided to delay application for a hearing.
April 1986	A dust control order was served obliging the plant to meet a schedule of improvements.

B.2 Public Information Program

The company's approach to the public information program was to make its message and method of delivery consistent with the nature of its business and the culture of the community in which the plant operates. The program was kept deliberately low key, personal and conservative but also comprehensive, open and responsive. The concerns expressed by the interest groups involved were taken seriously and responded to. Emphasis was placed on going out to talk to people rather than on the production of glossy and expensive public relations materials.

Informing the public about a technology is in itself difficult because of a lack of specialized knowledge. When that lack of knowledge is combined with a degree of fear and mistrust, the task becomes harder. Lafarge adopted a personal and honest approach to explain the waste management process in terms that could be understood by as many people as possible. Inevitably, presentations contained technical information, but steps were taken to make the material as clear as possible and to respond to any questions.

The reasons for the company's wish to burn wastes at Woodstock were clearly explained. A number of other topics were also discussed:

- the type of technology and operation involved;
- the link between fuel economy and plant viability;
- the number of personnel at the plant;
- the cement manufacturing process; and
- the type of waste material being burned.

Following the 90-day test burn, Lafarge was also able to include test results in the information communicated to the public.

In January and February of 1983, Lafarge arranged meetings with a number of representatives: Zorra Township, Oxford County, Woodstock and Ingersoll councillors, government representatives, the County Medical Health Officer, the local Energy Measures Coordinator and community leaders. The purpose of these meetings was to outline the proposed project to all these concerned individuals. Initially the response was favourable, but some negative response developed as a small group of local citizens began to oppose the project in a vocal manner. Lafarge remained in contact with the local officials and, whenever possible, corrected the misinformation being generated by the opposition group. Lafarge also contacted and met with representatives from Pollution Probe, the Canadian Environmental Law Association and the Ontario Public Interest Research Group. The general reaction by these groups was either noncommittal or negative.

B.3 Public Information Meeting

Towards the latter half of February, notices of a public meeting, scheduled for March 2, 1983, were published in six local newspapers. Interviews were held with journalists at the time to ensure a more broadly based media outline of the project for the general public. At the public meeting, held in Embro, Lafarge and SYSTECH personnel met with about 120 local citizens. An oral presentation of the proposal was made, and written information was distributed. Questionnaires were also handed to everyone present so that questions not addressed during the meeting could be answered later. All questions directed through local politicians or Woodstock employees were also answered promptly and in writing.

The public meeting was not required in order to obtain approval for the project, but it formed part of Lafarge's plan to be as open and accessible as possible. The meeting also served to encourage people's involvement in a project to be located in their community. It also formed part of the company's agreement with Environment Canada.

Lafarge and SYSTECH representatives were well prepared for the meeting but a barrage of constant interruptions from a small but highly vocal group of opposed citizens made it impossible to complete the presentation. Approximately 90% of the questions asked came from the same five or six individuals. As the public meeting progressed, it became apparent that it had become a forum for the opposition rather than a medium for the exchange of information. This served to strengthen the position of the opposition.

B.4 Other Public Information Programs

Open House at the Woodstock Plant

The extended test burn ran from October 5 to December 28, 1983. During this period, Lafarge opened its doors to the public so that people could gain a firsthand understanding of the waste management process. The open house was advertised in local newspapers and by means of a poster. In addition to this, letters of invitation were sent to all the people or groups with whom Lafarge had been in contact since January 1983. About

150 people toured the Woodstock plant and waste management facility while the test burn was in progress.

Presentations to Local Clubs and Groups

Beginning in May, 1983 and continuing late into 1986, information meetings were held with many different local interest groups. These included church groups, service clubs, agricultural organizations, educators and business associations. A list of the groups addressed by Larfarge representatives appears in Table B.1.

In advance of the required Environmental Assessment Hearing, and as indicated by Lafarge officials at the March 2, 1983 public meeting, results of the environmental testing program performed during the extended test burn would be released to the public in June, 1984.

Lafarge responded in writing to all questions regarding the waste disposal project. The company also sent out information brochures upon request.

B.5 Concerns and Opposition Expressed by the Public

Some of the major concerns expressed during the public information programs were:

- risks perceived in the transportation, handling and burning of wastes;
- feared drop in property values associated with a waste management facility;
- lack of faith in regulatory agencies, Lafarge Canada and the waste management company;
- a deep-seated suspicion of "big business" and a reluctance to believe anything it says;
- no cost/benefit to the community which feels itself to be at risk;
- volume of available wastes;
- neighbours complaining about dust, noise, odours and vibration from the cement plant;
- a concern that the plant might later become a waste incineration facility; and,
- environmentalists concerned about the impact of a resource recovery installation.

Although not many people were opposed to the Woodstock project (approximately 20), they were vocal, active and determined. The opposition consisted of four groups:

Table B.1 Service Clubs and Groups Included in the Public Information Program (May 1983 to May 1986)

Woodstock Optimist Club
Embro Women's Institute
Ingersoll Chamber of Commerce
Ingersoll Kiwanis
Rotary Club of Woodstock-Oxford
Woodstock and District Industrial Management Club
Ontario Federation of Agriculture
Christian Farmers' Association
Oxford Federation of Agriculture
Oxford County Firefighters' Association
Sir Wilfred Laurier High School (eight science teachers)

- a "Not in my backyard" group upset by the nearness of the project to their homes;
- concerned environmentalists apprehensive about the safety of the project;
- disgruntled neighbours who resent the presence of the plant; and
- individuals who are not averse to publicity and the attention of the press.

A lobby group called the Embro Concerned Citizens Committee was formed following the public meeting. The 14 members of the committee gained a good deal of coverage in the press, wrote letters to the editor, and contacted local officials and politicians with statements of concern. They were invited to tour the Woodstock plant on November 9, 1983 and did so. The principal objective of the Concerned Citizens Committee was to persuade the Ontario Ministry of the Environment to require Lafarge to submit their waste management proposal to an Environmental Hearing. Due to the improvements required at Woodstock, the MOE met with the group and, in mid-May, agreed to this request. It was therefore decided to delay applying for a hearing until the problem had been corrected.* In April 1986 the plant was served with a control order. Excellent progress has been made in improving emission control, but this has served to provide the Concerned Citizens Committee with continued ammunition for their opposition.

B.6 Role of Plant Employees and Media

The first people to be informed of the proposed resource recovery project were the plant employees themselves. If they were convinced about the viability and safety of the project, they could become the most effective means of conveying this confidence to their neighbours in the community. Beginning in August 1982, employees at Woodstock were informed of the project through presentations at general and individual departmental meetings. Visits were also made to Paulding, Ohio to see the facility in operation and to study the health and safety aspects of the operation.

In order to establish a "personal" and consistent approach to public relations in the community, the plant manager was selected as the spokesperson for the Woodstock plant. He was joined at some meetings, depending on their size and audience, by other experts from Lafarge and SYSTECH.

Press coverage of the various stages and aspects of the project was extensive and generally fair. The company contacted the local newspapers, providing interviews and information. The newspapers followed the project closely and reported events accurately. Generally speaking, the company attempted to maintain a low profile. It responded to all questions but was reluctant to become involved in a press debate. As the opposition group engendered negative comments, Lafarge's stance was perceived, not surprisingly, as becoming somewhat more defensive.

In December 1986, the company conducted a review of all available newspaper clippings about the supplementary fuels program. These came from newspapers published in the towns surrounding the plant and spanned the years 1983 to 1986. The purpose of the review was:

- to gain an objective picture of all newspaper coverage since the proposed project became widely known;

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* The results of the extended test burn were supportive of the supplementary fuel project, but it was found that some areas of the Woodstock plant required dust control improvements.

- to learn the names, affiliations and attitudes of groups and individuals publicly active in the events from 1983 to 1986; and

- to see what lessons could be learned and applied to actions contemplated or undertaken in the future.

B.7 Observation

The merit of forming a liaison committee or a citizen's advisory committee remains uncertain. When Environment Canada suggested a liaison committee be formed before any public encounter related to the Woodstock project, Lafarge declined. A later offer made by the company to the Embro Concerned Citizens Committee to form such a committee was turned down.

It is difficult to assess whether the existence of such a liaison group would have altered the course of the project. The effectiveness of a liaison committee depends on a number of factors, including its competence, diligence and credibility with the public at large. However, the question of forming such a group when applying for a future resource recovery permit would be given very serious consideration.

Before embarking on a project for a resource recovery installation in a community, the operator should have an accurate assessment of how such a project is perceived by that community. In retrospect, the personnel at the Woodstock plant have been slow in responding to the growing environmental concerns of the general public. It should be borne in mind that public focus on a project of this nature may include other problems at the plant, past or present. The operation should therefore be in compliance with all environmental standards before embarking on a waste management project.

One of the least successful techniques in gaining public acceptance of a waste management project is proving to be the large public meeting. Lafarge's experience in March 1983 bears this out. The optimum number of people appears to be 25 or less. It has been observed that large meetings do not provide a good forum for the exchange of information. Instead they serve to provide a forum for mobilizing the strength of the opposition and the press media tends to report the most dramatic aspects of the meeting.

Some of the elements commonly recognized as essential to a good public involvement program are identified in Table 2. It also demonstrates how Lafarge would rate its own performance according to the program elements listed.

Table B.2 Elements Included in the Lafarge Public Involvement Program

Program Element	Rating
Responsiveness to the real concerns of the community	Responsiveness was good and immediate, but more research could have been done in areas such as property values
Personal contact with community and its leaders	Very good
Appropriateness and forthrightness of public information program	Very good
Awareness of how community perceived the plant	Inadequate
Encouragement of public involvement and input	Not good initially, but improved as program got underway
Preparedness - degree of long-term, integrated planning	Insufficient
Gaining support of plant employees	Generally speaking, they were positive or neutral about the project
Regular briefings of the media	Good
Formation of citizens' liaison committee	Not done
Suitability and effectiveness of spokesperson	Very good
Technical investigation of project and validity of environmental test results	Good, but the need to improve other environmental conditions at the plant negated this aspect of the program

Appendix C

Procedures and Permits Required for the Woodstock Project

In June of 1982, Lafarge outlined its proposal to use combustible liquid waste as fuel for the Ontario Ministry of the Environment and for officials from the Ministry of Energy. The objective at this time was to determine the procedures for developing a supplementary fuel program at the Woodstock Cement Plant. After this meeting, it was determined that Lafarge would proceed in the following stages based on the procedures established and permits required.

Stage I - Preliminary Test Burn

A preliminary test burn was to be undertaken to confirm the acceptability of combustible liquid waste fuels in the kiln burning process. The most important objective of this preliminary burn was to conduct strict fuel specification compliance testing. No permit would be necessary, but once the test starting date was known, Lafarge was required to notify the London office of the MOE so that they could have an observer present during the test.

Stage II - Extended Test Burn

An extended test burn was to be undertaken if the preliminary test burn results were encouraging. This extended test burn was designed to determine any potentially adverse environmental impacts and to clarify whether or not an application would be made for permanent status. For an extended test burn of about three months duration, an air permit was required before commencement, according to the *Environmental Protection Act*, Section 8.

In conjunction with the design and construction stage, an application for a Certificate of Approval (Air), under Section 8 of the *Environmental Protection Act* was made on January 7, 1983. On July 14, 1983, the Ministry of the Environment granted Lafarge three temporary operating permits:

1) Certificate of Approval (Air), *Environmental Protection Act*, Section 8, for the right to use combustible liquid waste as fuel in a rotary cement kiln;

2) Certificate of Approval (Air), *Environmental Protection Act*, Section 8, for the right to store combustible liquid waste in two 65 000-L tanks; and

3) Certificate of Approval (Waste disposal/processing), *Environmental Protection Act*, Part V, for the right to operate a combustible liquid waste storage, blending and transfer site.

Originally, a test protocol for the extended test burn was developed by Lafarge with recommendations from the Ontario Ministry of the Environment, Air Resources Branch. The protocol was incorporated as part of the issuance of the above permits as a requirement for proceeding. After being issued three temporary operating permits, Lafarge was required to undergo an Environmental Assessment Hearing before a permanent resource recovery facility could be established. This requirement, which was under Part V of the *Environmental Protection Act*, would be used to publicly assess the proposal for a permanent facility on the basis of the extended test burn results.

Pollution control provisions for the extended test burn were also required under the Official Plan for the County of Oxford where the Woodstock plant is located. Under the

Official Plan, Section 5.4.4.4 *Pollution Control Requirements*:

"All permitted uses must satisfy the requirements of the Ministry of the Environment as to water supply and sewage disposal, and emission, including dust, noise and vibration."

From the standpoint of compliance with the Official Plan, the proposal to store and burn combustible liquid waste fuels and to dispose of the waste precipitator dust in the present on-site landfill site is consistent with the above-noted policies.

Stage III - Permanent Installation

For a permanent installation, it was clearly understood that it would be necessary for Lafarge to obtain two permits:

1) Air Permit - *Environmental Protection Act*, Section 8, for the fuel modifications, the burning technology and the emission controls; and

2) Waste Management Permit - *Environmental Protection Act*, Part V, for the waste management facilities.

Further communications were initiated with the MOE between June and September, 1982 to reaffirm the Ministry's procedural requirement of Lafarge, to introduce Lafarge staff to the local Ministry officials and to indicate proposed and revised starting dates. The preliminary test burn was scheduled for September 1982.

In order to proceed, Lafarge required the capability and methodology for procuring the combustible liquid waste to be used as fuel. Initially, the equipment and personnel to procure the waste were not available within the Lafarge organization. At that time, there was no incentive to become involved in the business of procuring combustible liquid waste. As a result, arrangements were made with SYSTECH Corporation of Xenia, Ohio to provide combustible liquid waste procurement services.

As part of the 1982 test program, SYSTECH accepted the fuel procurement responsibilities and agreed to:

- provide Lafarge with about 91 000 L of combustible liquid waste from the Paulding facility in order to complete the preliminary test burn;
- perform a market survey for combustible liquid wastes to assess the feasibility of a permanent project at the Woodstock plant;
- develop a source of combustible liquid waste so that the later extended test burn could be procured from the Ontario market to demonstrate the result of the market survey; and
- provide a long-term fuel procurement service under contractual arrangements with Lafarge in the event of the establishment of a permanent waste management facility.

C.1 Plant Setting

Lafarge's Woodstock plant and quarry are located in the Township of Zorra, Concessions II, III and IV, on parts of Lots 1, 2, 3, 4 and 5. The plant proper is located on Lot 1, Concession IV directly north of Highway No. 2 (Governor's Road). Agriculture is the dominant land use surrounding the plant and quarry. A variety of land use exists along County Road No. 6 (Embro Road) east of the plant. Agricultural lands extend north from Highway No. 2 along the east side, to just south of the CPR right-of-way. Two industrial uses, Oxford Plastics Inc. and Laidlaw Waste Systems, are situated south of the railway lands and on the east side of the Embro Road. To the north on the same side is another commercial activity - Hesston Farm Service. East Zorra Township is part of Oxford and consequently falls under the Official Plan for the Oxford planning area.

The Official Plan was approved by the Minister of Housing on April 17, 1979.

C.2 Zoning By-law Considerations

The Lafarge Plant and Quarry lands are zoned under the Township of Zorra Zoning By-law No. 53-1980 as Quarry Industrial Zone (M3). Uses permitted in this zone which are relative to cement manufacturing include:

"Section 21.1.2 (part list)

- an aggregate storage area;
- a cement-manufacturing plant;
- a crushing plant;
- a lime-manufacturing plant;
- a stone quarry and accessory uses; and
- a business office accessory to a permitted use."

Modification to the fuel storage area and the on-site plant waste disposal site are considered to fall within the definition for "accessory" uses which are set out as follows:

"Section 2.1 *Accessory* when used to describe a use, building or structure means a use, a building, or a structure that is normally incidental, subordinate and exclusively devoted to a main use, building or structure and located on the same lot therewith."

The proposal for the modification of the Woodstock plant to allow for the burning of selected combustible liquid wastes as supplementary fuel and to improve the on-site plant waste disposal site, does not necessitate any amendments to the County Official Plan and the township zoning by-law.